Operating & Maintenance Instruction Manual
For
Noise & Level Measuring Set
Model 816A-1, -2

Serial No. _____

BOWMAR

BOWMAR / ALI, Inc.

A SUBSIDIARY OF BOWMAR INSTRUMENT CORPORATION

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MANUFACTURED BY:

Bowmar/ALI, Inc.

531 Main Street

Acton, Massachusetts U.S.A. 01720

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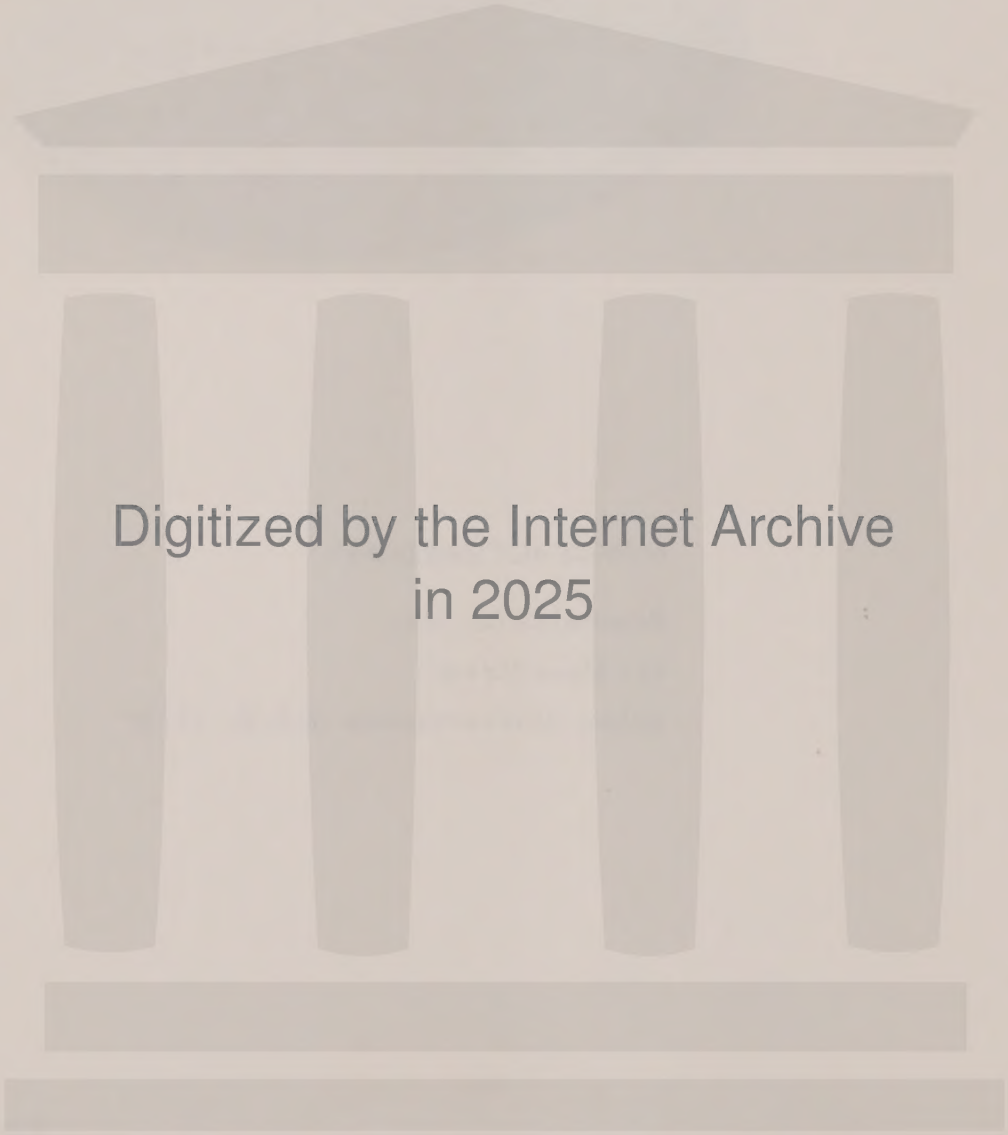
May 1974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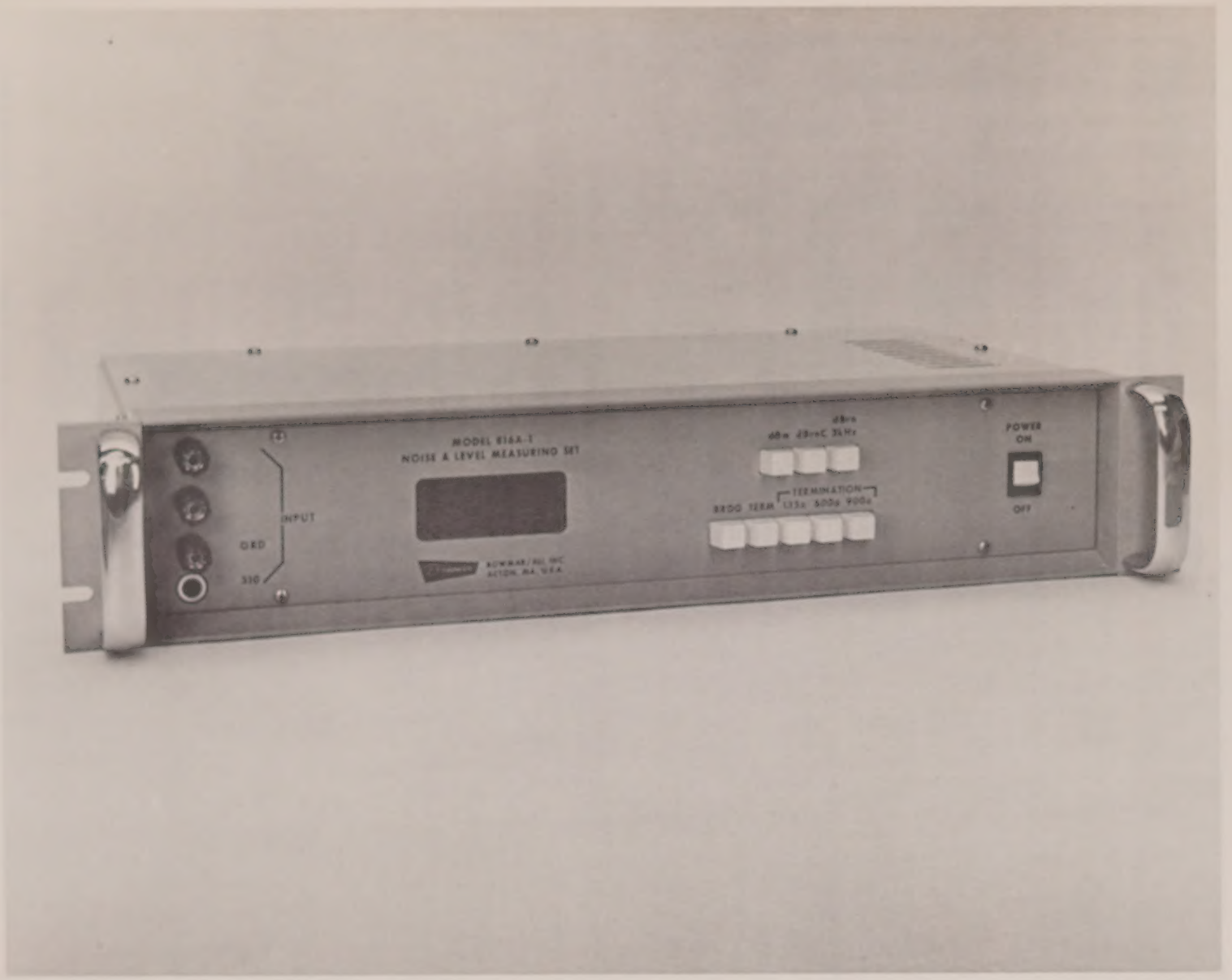
MODEL 816A-1
NOISE & LEVEL MEASURING SET
INPUT
GRD
dBrn
dBm dBrnC 3kHz
TERMINATION
600Ω TERM
POWER
ON
OFF

MODEL 816A-2
DIGITAL LEVEL MEASURING SET
INPUT
dBm
dBrn dBrnc
TERMINATION
BRDG TERM 135Ω 600Ω 900Ω
POWER
ON
OFF
BOONTON/ALI INC.
ACTON, MA. U.S.A.

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CHAPTER 1

INTRODUCTION

1.0 Description

The 816A Noise and Level Measuring Set is basically a logarithmic reading voltmeter fitted for direct use with communications circuits systems or devices and calibrated for the output level ranges and established impedances of such systems.

1.1 Scope of Manual

Included herein are instrument specifications, theory of operation, operational instructions, basic troubleshooting approach, schematics and essential drawings, and a parts list. These items are presented to permit ready reference for installation, use, and maintenance of the Noise and Level Measuring Set.

1.2 Designation

'816A' is the generic designation assigned to this series of Noise and Level Measuring Sets, manufactured by Bowmar/ALI. The various models of this series will be identified by the generic designation suffixed by a "dash number", such as 816A-1, 816A-2, etc. The succession of models will come as a result of modifications made to suit specific customer requirements or to introduce design improvements. The complete designation number along with serial number should be referred to in all correspondence related to any instrument in this series.

1.3 Specification Summary

INPUT

Level Range	-60 dBm to +20 dBm, 0 dBrn to +92 dBrn
Frequency Band	50 Hz to 110 kHz or C message weighting (or 3 kHz low pass weighting in the 816A-1 only).
Resistance	135, 600, and 900Ω plus bridging at 246 KΩ // 32 pF (123 KΩ//64 pF each side to ground).
Fault Voltages	(a) Meets all specifications with 400 Vdc to ground (b) Meets all specifications with nominal 48 Vdc on line

	(c) Undamaged by 105 V rms 20 Hz ringing signal in bridging positions.
Holding	Telephone set may be plugged into unit, dialed, and circuit held.
Overrange	Digits are blanked, with + and - signs indicating direction of out of range signal.
DISPLAY Type	816A-1: Solid state numeric display in direct dBm or dBrn. 816A-2: Solid state numeric display in direct dBm or dBrn with provision for external readout via BCD output.
Response	Measures pseudo rms value of input signal.
Characters	3 decimal digits, with decimal point and polarity indicators; buffer storage eliminates flicker. (2 decimal digits on dBrn)
Ranging	Fully automatic, no operator adjustments.
Accuracy	±0.1 dBm
Resolution	0.1 dBm, 1 dBrn automatically rounded.
Transition Ambiguity	Less than 0.01 dBm.
OPERATING ENVIRONMENT	0°C to +55°C (+32°F to +120°F); to 95% relative humidity.
PRIMARY POWER	115/230 Vac, ±10%, 47 to 480 Hz, single phase.

1.4 General Background

In communications systems, measurements are frequently made in dBm at terminating impedances of 135, 600, and 900 ohms. Traditionally, such measurements are made on an analog device, the measured value usually being the resultant of an attenuator setting to which a meter reading is either added or subtracted. It usually is necessary for the operator to change the attenuator setting each 10 dBm increment. The 816A Digital Noise and Level Measuring Set, on the other hand, provides automatic ranging throughout its full range, completely eliminating the necessity for mental arithmetic and manual switching. Both the polarity sign and the actual dBm or dBrn value are automatically presented. The resolution also remains constant at 0.1 dBm regardless of the value being measured.

Typically, the standard 816A provides a weighted peak or average indication (pseudo rms) of measured power, based on the assumption that it is measuring a sinusoid or an input of Gaussian probability density, as is most noise. The true rms value, however, is equal to the heating value of the applied voltage, regardless of waveform. Another noteworthy option for the 816A is provision for external readout. Access to this option is via a rear connector.

The frequency range of the 816A has been chosen to cover those bands which are most frequently used for voice, wide-band program, analog, and digital data transmission. The accuracy specification statement covers the entire frequency range under worst case environmental conditions. The unit may be used to terminate lines of 135, 600, and 900 ohms or, where desirable, can be used to bridge the line with an impedance of greater than 200 KΩ. The unit may also be readily used in the laboratory during design and evaluation. Its balanced and floating input with high rejection of longitudinal voltages ideally suits it to this use. In production testing and quality assurance monitoring, the 816A can be used by personnel who have a minimum of technical training. Readings are presented without ambiguity or the necessity of mental calculations.

The unit may also be safely employed on wire lines used in the dial telephone network. All input circuitry is designed to meet or exceed current Western Electric Company requirements for input fault and ringing levels. A telephone test set may also be dialed through the unit by use of the jack and controls provided.

CHAPTER 2

INSTALLATION

2.1 Preparation and Installation

2.1.1 Remove Noise and Level Measuring Set from case.

2.1.2 Check for presence of proper fuses (3/10 A, slow blow) at the rear panel.

2.1.3 Place the POWER switch in its OFF position.

2.1.4 Set the 115/230 Vac switch according to the line voltage to be used.

2.1.5 Connect the power cord to the appropriate line voltage supply.

2.1.6 Set front panel switches according to measurements to be made and proper termination.

2.1.7 Connect to the equipment under test via the rear panel terminal strip or the front panel jacks.

2.1.8 With the 816A-2, if external readout is to be used, make the necessary connections from the BCD Output Connector at the rear panel.

2.1.9 Place the POWER switch in its ON position.

2.2 Operation

The Measuring Set will respond immediately to any input. If response appears incorrect, check the Set against a standard signal source, or by substituting a similar instrument. If a malfunction is indicated, consult Chapter 5 for troubleshooting procedures.

CHAPTER 3

OPERATION

3.1 Controls, Indicators, and Connectors

3.1.1 Controls

3.1.1.1 Function Switches (to select type of reading)

816A-1: three push-switches; dBm, dBrnC and dBrn 3 kHz

816A-2: two push-switches; dBm and dBrnC.

3.1.1.2 Load Switches

.1 BRDG - Enables measurement at a point in a system without disturbing signal levels due to loading effects.

.2 TERM - Enables a terminated measurement at the output of a system.

.3 TERMINATION - The termination options of 135Ω, 600Ω, or 900Ω are applied by depressing the corresponding push-switch. These calibrate the Measuring Set for 0 dBm = 1 mW at each impedance in addition to choosing the proper impedance for terminated measurements.

3.1.2 Indicators

Internal Display

3 digit L. E. D. (Light Emitting Diode) Display with decimals and polarity sign.

3.1.3 Connectors

3.1.3.1 Front Panel

Three banana jacks, two red for floating input and a black for ground, allow use of GR plugs for measurements. An additional jack, of telephone type, is provided to accept a WE type 310 plug for dial-thru or measurements.

3.1.3.2

.1 A terminal strip on the rear allows use of screw-in test connections. These terminals are paralleled with the front panel jack and the banana jacks.

.2 On the 816A-2 only, a connector for channelling BCD display information to an external display. Cabling to this connector must be fitted with a Cinch-Jones Model DCF-25P or equivalent connector. (Refer to Figure D816-105 for pin connections.)

3.2 General Operating Procedures

3.2.1 Preliminary Settings

.1 If the Measuring Set contains the B. C. D. Interface Display option and its use is desired, connect the necessary interface cable. The cable requires a Cinch-Jones #DCF-25P connector, or equivalent, to mate with the Measuring Set.

.2 Connect the system or instrument to be measured to the desired Input terminals or jacks of the Measuring Set.

.3 Depress the appropriate TERMINATION switch (135Ω, 600Ω, or 900Ω).

.4 Depress the BRDG (Bridging) or TERM (Term) switch, according to the system test point.

.5 Set the Function switches for the type of reading desired: dBm or dBrnC (or dBrn 3 kHz on the 816A-1).

3.2.2 Test Run

When properly connected, the Measuring Set will display readings immediately. Should the readings suggest error or improper performance, check preliminary settings, then check for proper system performance. If a malfunction of the Measuring Set is suspected, refer to Chapter 5 on troubleshooting.

CHAPTER 4

THEORY OF OPERATION

4.1 General

The Noise and Level Measuring Set is a logarithmic reading digital voltmeter calibrated to read dBm, dBrn, and dBrnC on 135Ω, 600Ω, and 900Ω circuits. It features automatic range selection between limits of -62 to +22 dBm or 0 to 92 dBrn and offers either a flat frequency response from 50 Hz to 110 kHz or "C" Message weighting. In the 816A-1, frequency response also includes the option of 3 kHz low-pass weighting. Its display is corrected to give direct readings of dBm or dBrn, so that operator calculations are unnecessary.

Refer to the Block Diagram (Figure 4-1) as an aid to the functional description that follows.

Since the Measuring Set is essentially an auto-ranging dB meter, its basic functions are

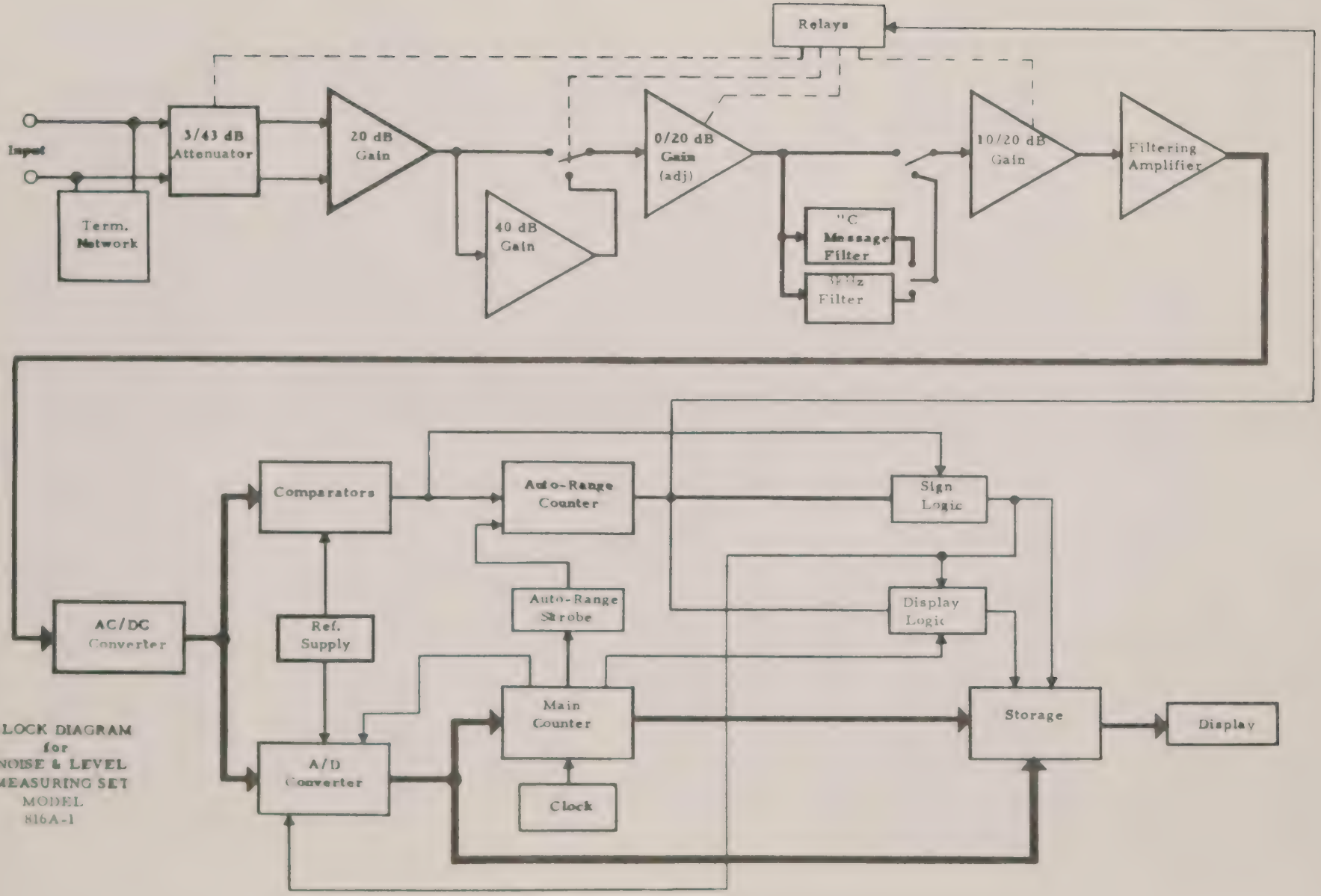
A. to automatically adjust to the level of signal being measured.
B. to compare the signal being measured with a fixed reference voltage to determine dB level.
C. to present a visual indication of the measured dB level.

The Set performs these functions by processing the quantity to be measured in three different formats.

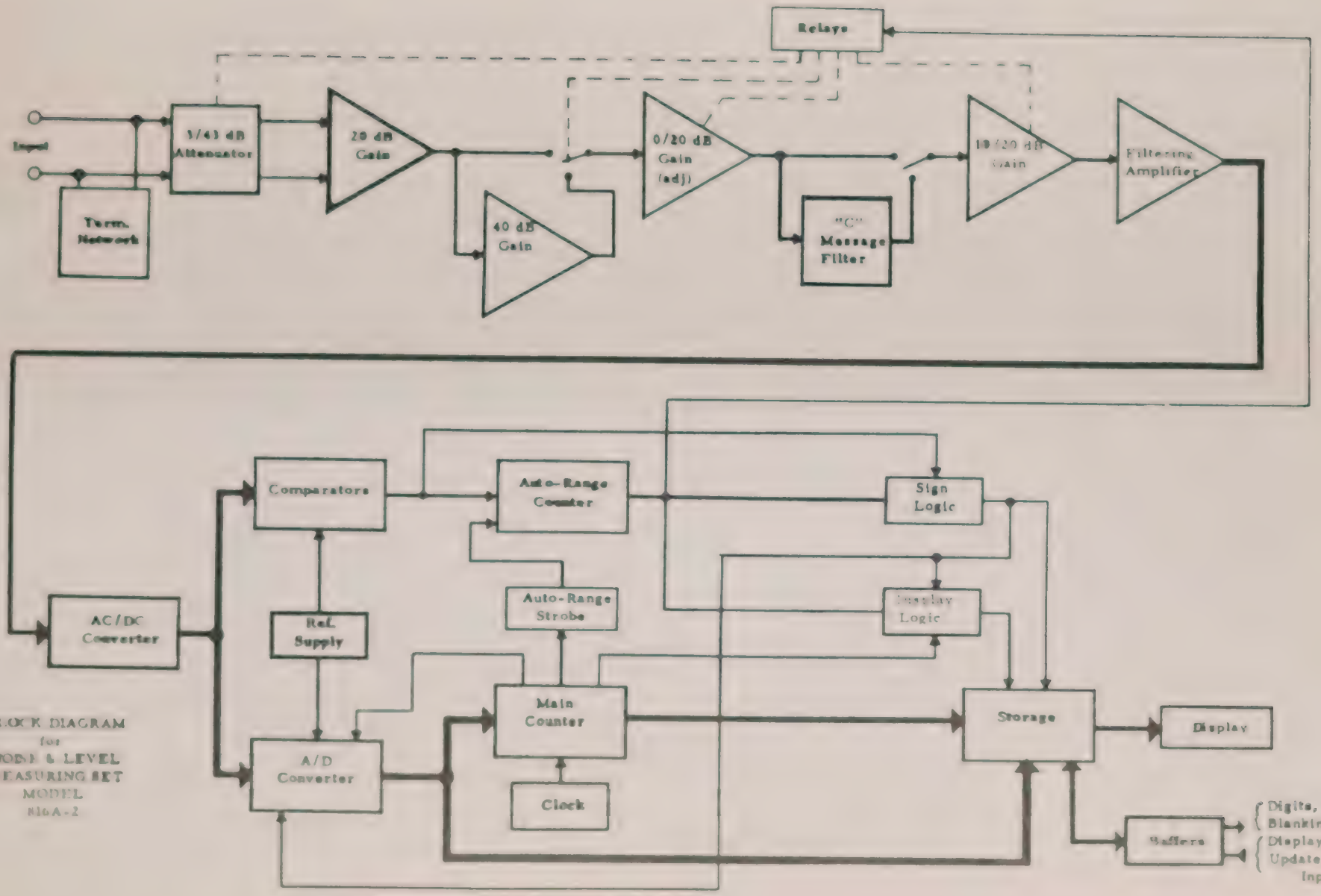
1. the original AC state
2. a D.C. Analog of the original AC
3. a digital representation of the measured dB level.

The Measuring Set's first basic function, automatic adjustment to the level being measured, is more simply referred to as "auto-ranging". With this capability, the Set can switch itself through either its -62 to +22 dBm or its 0 to 92 dBrn ranges in nominal increments of 10 dB (actually, a 2 dB overlap at each increment gives 12 dB). The process is performed in the AC signal section through a switchable AC attenuator and a series of switchable AC amplifiers.

From the Measuring Set's input terminals, an incoming AC signal is applied to a termination network whose components are preset by the operator to match the impedance of the circuit being measured. The next stage is a dual-range AC attenuator which acts as a buffer between incoming signals and the series of AC amplifiers. Auto-ranging is accomplished by switching the AC attenuator and amplifiers through various possible combinations until the signal being measured is in-range. Switching is triggered in binary fashion, and the Set's ranges are stepped through in consecutive order.



BLOCK DIAGRAM
for
NOISE & LEVEL
MEASURING SET
MODEL
816A-1



BLOCK DIAGRAM
for
NOISE & LEVEL
MEASURING SET
MODEL
N6A-2

Switching for the auto-ranging process is performed by a bank of relays whose contacts are tied to the AC attenuator and amplifiers. Appropriate relays are energized for each range increment according to binary signals. Four-bit binary instructions are issued by the Auto-Range Counter. These outputs are routed as issued or inverted to proper relays. The Auto-Range Counter issues its binary instructions in response to signals from comparator circuits which determine whether or not the AC section is in-range. (Comparator circuits are described more fully, below.)

The four-bit binary instruction from the Auto-Range Counter changes only in response to "count-up" or "count-down" signals from the comparators. The Auto-Range Counter is strobed to sample these comparator signals and issue corresponding four-bit instructions approximately three times per second. Instructions are such that the AC section is incremented only one range step per strobe. This rate is slow enough to allow relays and filter sections ample periods for stabilization between switching. At the same time it provides virtually constant monitoring of the signal being measured and reasonably rapid response to large changes in signal level.

Included in the AC section is a "C Message" filter. The filter may be switched into use at the option of the Measuring Set's operator to apply "C Message" weighting. In the 816A-1, a 3 kHz low-pass filter is included in addition to the "C" Message filter to offer an additional option of response weighting.

Following the AC section is the AC/DC Converter which rectifies and filters the AC signal being measured to give a DC Analog representing the AC signal. Beyond the AC/DC Converter are the Comparator circuits, which work in conjunction with the Reference Supply. The Reference Supply generates two precise reference voltage levels that are 10 dB apart; thus it provides a 10 dB Reference Range by which the Comparator circuits determine whether the AC section is in-range. When the AC section is in-range for the signal being measured, there will be no Comparator output, hence no new four-bit instruction from the Auto-Range Counter. But should the signal being measured be above or below the existing range setting, the DC Analog will be above or below the Reference Range accordingly and cause a corresponding Comparator output change. The Auto-Range Counter will respond by incrementing its binary count up or down, one step per each 3.125 Hz strobe. With each new binary count, the AC section will be switched up or down through successive ranges until the level of the signal being measured is accommodated and Comparator output has returned to zero.

The Measuring Set's second basic function, comparing the signal being measured with a fixed reference in order to determine dB level, is accomplished in the Analog/Digital Converter. This circuit utilizes a principle common to Resistor/Capacitor (RC) circuits, whereby the time required for discharge of an RC circuit from one voltage to another is proportional to the logarithm of the ratio of the two levels. The mathematical expression for this principle is

$$T = RC \ln(10) \log_{10} (V_i/V_f) = \text{time of discharge between } V_i \text{ and } V_f$$

The standard expression for dB in terms of a voltage ratio is

$$dB_v = 20 \log_{10} (V_1/V_2)$$

The two expressions differ only in their multiplicative constants. If values for RC are chosen so that

$$RC \ln(10) = 20$$

then T, of the first expression, may be equated to the level difference in dB between the initial voltage V_i and the final voltage V_f of the RC circuit.

In the Analog/Digital Converter, the DC Analog of the signal being measured and one of the two precision voltages from the Reference Supply are used to control discharge time T of the RC circuit. For levels to be expressed as negative dB quantities, the RC circuit is initially charged to the larger of the two reference voltages and discharged toward ground to the magnitude of the DC Analog. For positive dB quantities, the RC circuit is initially charged to the DC Analog and discharged to the smaller reference voltage. In both situations the discharge from the initial level to the final level is timed.

Discharge of the RC circuit begins when the main portion of the Set's Counter contains all zeroes and is ready to start a new count. The Counter then times the discharge which ends when a comparator circuit signals that the voltages at its two inputs, the RC voltage and one of the two reference voltages, are equal. At this instant, the Counter is momentarily stopped and its contents dumped into a storage register, from which the dB reading is displayed. The Counter starts anew with each RC charge-discharge cycle, with the entire cycling process repeating at a 125 Hz rate.

The Storage Register holds the Display constant between cycles of the Analog/Digital Converter to provide a flickerless presentation.

Before Counter contents are dumped into storage, the most significant figure of the accumulated count must be adjusted. This adjustment considers range-settings of the AC section, whether the dB level is to be expressed as a dBm or dBrn quantity, and whether the algebraic sign is to be positive or negative.

Remember that when the AC section is properly adjusted for the signal being measured, the resultant DC Analog level falls somewhere between a 12 dB range established by the two precision voltages of the Reference Supply and divider networks at the inputs of the Comparator (the purpose of the dividers is to add an additional 2 dB to the 10 dB reference-range). Thus, regardless of the actual magnitude of AC signal being measured, the level of DC Analog sampled by the Analog/Digital Converter will always be within the established 12 dB range. The most significant digit must therefore be changed to bring final readout in line with the level of signal being measured.

4.2 Terminating Network

The Measuring Set may be set for both terminated and bridging type measurements. For terminated measurements, the Set's operator may select any one of three resistances which represent standard terminating impedances for typical communications systems. Values of 135Ω, 600Ω, and 900Ω are held to 0.1% accuracy, while power capacity is sufficient to handle commonly encountered overloads and to allow "holding" a circuit without the use of frequency dependent inductors. These resistances may be selected by the TERMINATION Switches on the front panel. Each switch is labelled according to its corresponding resistance.

Selecting a terminating resistance simultaneously adjusts the Measuring Set's calibration for 0 dBm or 90 dBrn = 1 mw into the selected resistance. This adjustment is made through an extra set of switch contacts on each TERMINATION Switch. As a switch is actuated, its corresponding resistance is tied to the Measuring Set's inputs while a corresponding gain adjustment is tied into the amplifier circuits.

For bridging measurements, the BRDG Switch must be actuated. This switch removes the selected termination resistance from the input terminals, since in a bridging capacity the Measuring Set is not to act as the terminating device. At the same time, however, the TERMINATION Switch for appropriate resistance must remain depressed to maintain correct calibration of the amplifier section.

Referring to the Main Schematic, in Chapter 6, TERMINATION Switch sections are designated S2, while resistances are R1, R2, and R3 for 135Ω, 600Ω, and 900Ω respectively. The BRDG Switch is S1. Amplifier gain adjustments are made via the S2 terminals at the input of the 10/20 dB Amplifier. Coupling capacitors C1 and C2 serve to block D.C.

4.3 3/43 dB Switchable Attenuator

Input circuitry of the Measuring Set is protected by an AC attenuator which may be switched from 3 to 43 dB. The Attenuator provides a constant bridging

resistance of greater than 200 KΩ (typically 246 KΩ in parallel with 32 pF; 123 KΩ in parallel with 64 pF, each side to ground) while serving as a buffer to transient overloads and fault conditions.

Switching is performed by contacts of the K1 relay, whose drive circuit responds to signals from the Auto-Range Counter. In K1's energized state, the Attenuator is in its 43 dB mode, which is depicted in the Main Schematic of Chapter 6.

Capacitors C3, C6, C9 and C10 are adjustable for optimum Attenuator frequency response across the specified band. Adjustment procedures are given in Chapter 5.

4.4 20 dB Fixed Gain Amplifier

A 20 dB fixed gain, low noise amplifier with high input impedance, allows balanced or unbalanced terminated or bridging measurements at all frequencies. Two half-sections of IC1 in a balanced arrangement perform the actual amplification. Both sections are configured as operational-amplifier voltage followers. However, they are designed to provide gain. The four diodes CR1-CR4 provide added protection to the inputs.

IC12A is used as a unity-gain amplifier whose purpose is to convert the dual-ended output from the operational amplifiers, to a single-ended output. A potentiometer at one of its inputs allows balance adjustments.

The single-ended output is fed directly to switch contacts of Relay K2. It may be switched to the input of the 40 dB Amplifier (Sec 4.5) or to the input of the 0/20 dB Amplifier (Sec 4.6).

4.5 40 dB Fixed Gain Amplifier

In its unenergized state, the K2 relay connects the output of the 20 dB Amplifier (Sec 4.4) directly to the input of the 0/20 dB Amplifier (Sec 4.6), thus bypassing the 40 dB Fixed Gain Amplifier. And when energized, K2 switches the 40 dB Amplifier into the AC amplifier chain between the 20 dB and 0/20 dB Amplifiers.

The 40 dB Fixed Gain Amplifier is inserted into the AC amplifier chain only for measurement of dBrn signals below 30 dBrn (equivalent to -60 dBm). It is a two-stage affair built around IC 2B and IC 3A. Both stages are configured identically.

4.6 0/20 dB and 10/20 dB Switchable Gain Amplifiers

Both Switchable Gain Amplifiers are under control of the Auto-Range Counter to limit AC signal level beyond their final output to approximately 12 dB.

10 dB is the advertised limit of each range step, however, a 2 dB overlap is added at the Comparators to eliminate "hunting" at cross-over points and needless range changes when measuring signals whose levels change slightly with time.

The 0/20 dB amplifier uses IC3B and is switched by the K3 relay, but a potentiometer (R32) allows fine adjustment of the overall system gain for purposes of calibration. The 10/20 dB amplifier uses IC4A and relay K4.

AC signals to the 10/20 dB Amplifier may be channeled through Resistor R52, R53, or R54 by Switch S2. The choice is made when S2 selects one of the terminating impedances described in Sec. 4. 2. Each of the resistors corresponds to a terminating impedance, and it sets correct amplifier calibration accordingly.

4. 7a "C" Message Filter

Frequency response of the Measuring Set is essentially flat across the specified band, unless "C" Message weighting is desired. The weighting is applied by channeling the AC signal being measured through the active "C" Message Filter. The filter approximates the standard "C" Message Curve (600 to 3200 Hz) within appropriate Bell System specifications.

The filter's input is permanently connected to the output of the 0/20 dB Amplifier. Depressing the dBrnC button, S6, of the front panel Function Switches energizes Relay K5 to switch the input of the 10/20 dB Amplifier to the output of the Filter.

Filter circuitry is four basic stages made up around IC's 5 and 6.

4. 7b 3 kHz Low-Pass Filter

The Function switch on the 816A-1 is identical to that of the 816A-2 except for an extra position labelled dBrn 3 kHz, which allows the operator to select a 2 stage - 3 pole low pass filter. This circuit adds one more option to frequency response for the 816A-1, flat response over a band 3 kHz wide at the low end of the frequency spectrum. The input of the 3 kHz Filter is tied directly to the input of the "C" Message Filter. Operating the Function switch to dBrnC or dBrn 3 kHz controls Relay K1, which switches the output of the "C" Message Filter or the 3 kHz Filter to contacts of Relay K5.

K5, in turn, switches the selected filter output, from contacts of K1, to the input of the 10/20 dB Amplifier. With the Function switch in dBm position, however, Relay K5 switches the input of the 10/20 dB Amplifier to the output of the 0/20 dB Amplifier, thereby bypassing both filters.

4.8 Frequency Compensation Amplifier

The final stage of the AC Amplifier chain is nominally of unity gain, but a filter network with capacitor (C55) adjusts the overall frequency compensation to allow a flat (±.1 dB) gain response of the amplifier over the 50 Hz to 110 KHz range. Its amplifier filter is built around IC4A and followed by an emitter-follower circuit which uses Q3. As with the other AC Amplifiers, this stage will handle waveforms with crest factors in excess of 12 dB and maintain large signal capacity to beyond 110 KHz.

4.9 Pseudo-RMS AC/DC Converter

AC/DC conversion takes place in a precision full-wave rectifier made up of two operational amplifiers. Rectifier diodes are placed in the feedback loop of the first operational amplifier; as a result they show no forward drop and are thus rendered ideal.

A 3-pole, low-pass filter is designed to yield the same output for both sine-wave and Gaussian voltage. The filter's time response meets requirements of Bell System Technical Reference PUB. 41009. These call for peak-to-peak variations shown in the following table for a 1 KHz tone gated at 50% duty cycle.

Gate Frequency	P-P Variations
12 Hz	1 dB
3 Hz	4 dB

The result of AC/DC conversion is a D.C. analog of the A.C. signal being measured. The level of D.C. analog is adjusted to correspond to the rms value of the A.C. signal.

4.10 Reference Supply

A dual section reference supply provides highly stable voltages of -1.897 volts and -6.000 volts. These values establish limits for each of the Measuring Set's 10 dB measurement steps. Both voltages are supplied to the Comparators and to the A/D Converter (See Sec.'s 4.12 & 4.13).

The lower voltage section is built around IC8 while IC7 provides the higher voltage. Both circuits are adjustable.

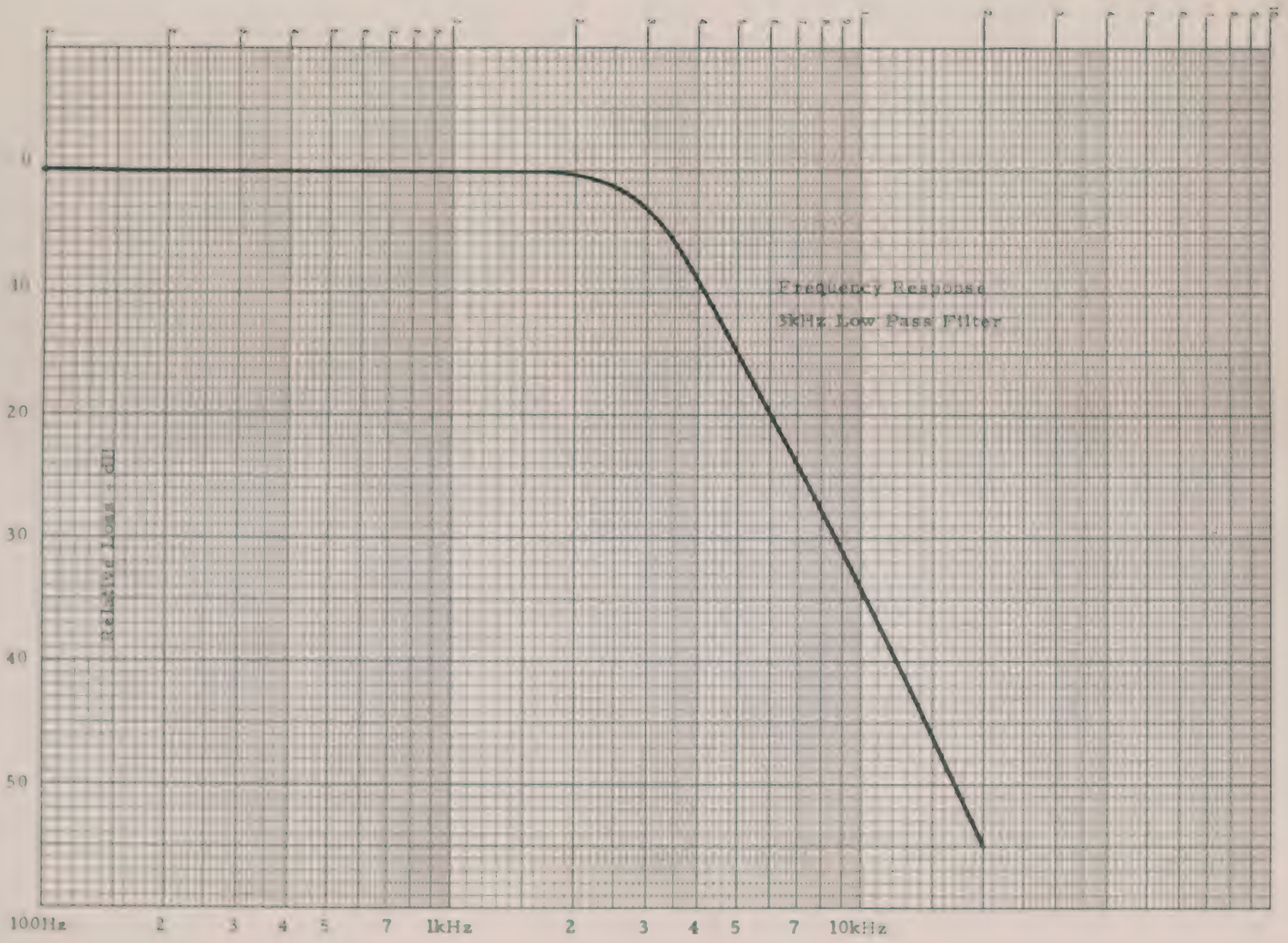
4.11 Master Clock and Counter

All control timing is derived from a 2.000 MHz crystal oscillator. Oscillator circuitry involves IC211.

Following the oscillator is a countdown chain made up of IC's 216A, 216B, 221, 220, 219, 213A and 213B. Frequency at each of these IC's may be read from the test points at their outputs as follows:

IC#	TP#	Frequency
IC216A	TP204	1 MHz
IC216B	TP205	500 KHz
IC221	TP206	50 KHz
IC220	TP207	5 KHz
IC219	TP208	500 Hz
IC213A	TP209	250 Hz
IC213B	TP210, 211	125 Hz

The 125 Hz output (IC213B) provides the sampling trigger for measurement of the D.C. analog signal from the AC/DC Converter. For this purpose it is directed to appropriate gates of the A/D Converter and to the Sign Logic.


Frequency Response
3kHz Low Pass Filter
Relative Loss : dB
0
10
20
30
40
50
100Hz
2
3
4
5
7
1kHz
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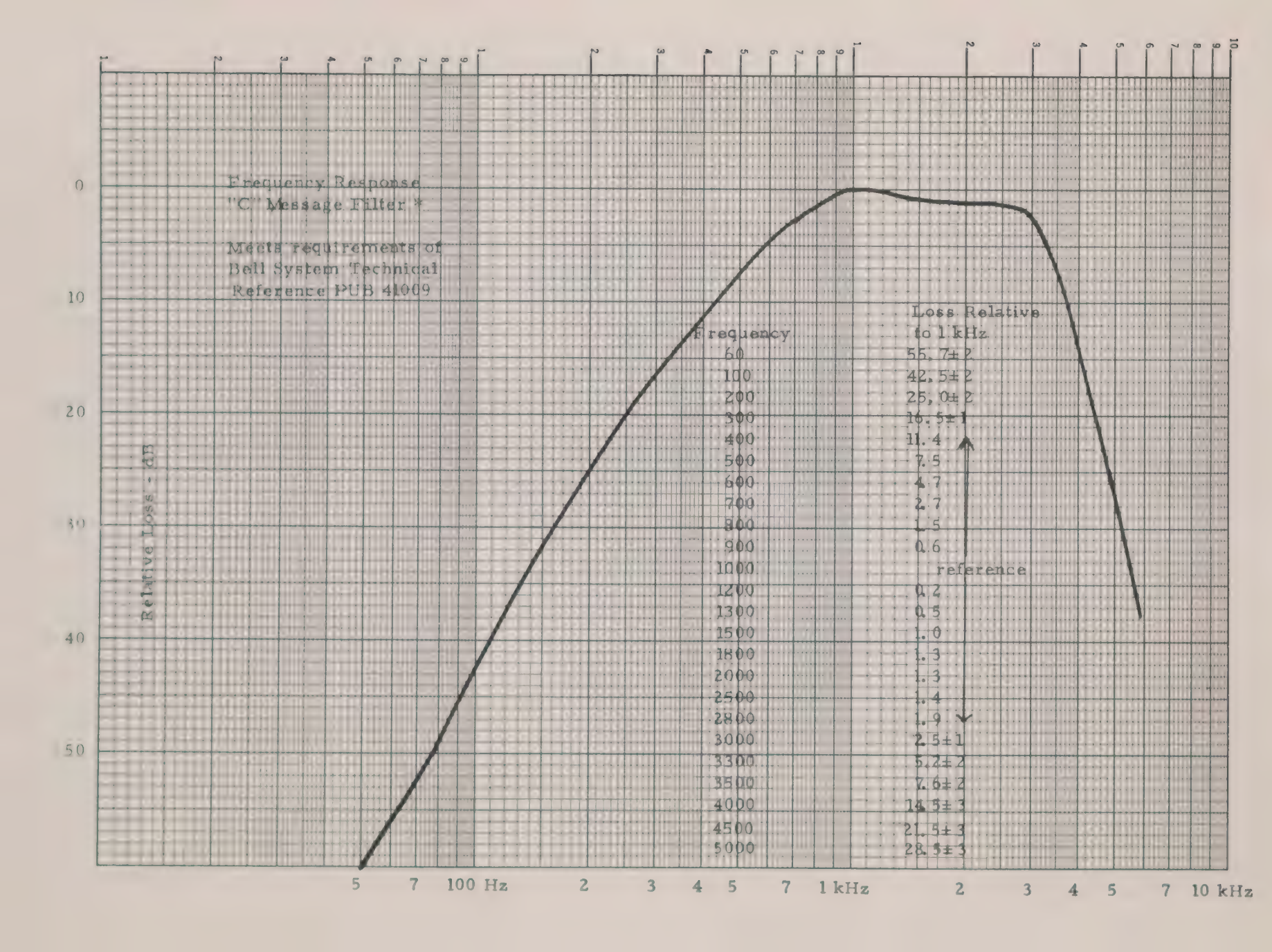
3
4
5
7
10kHz


Frequency Response
"C" Message Filter *
Meets requirements of
Bell System Technical
Reference PUB 41009
Relative Loss - dB
0
10
20
30
40
50
Frequency
60
100
200
300
400
500
600
700
800
900
1000
1200
1300
1500
1800
2000
2500
2800
3000
3300
3500
4000
4500
5000
Loss Relative
to 1 kHz
55.7± 2
42.5± 2
25.0± 2
16.5± 1
11.4
7.5
4.7
2.7
1.5
0.6
reference
0.2
0.5
1.0
1.3
1.3
1.4
1.9
2.5± 1
5.2± 2
7.6± 2
14.5± 3
21.5± 3
28.5± 3
5 7 100 Hz 2 3 4 5 7 1 kHz 2 3 4 5 7 10 kHz

The 125 Hz output is also routed through additional countdown circuitry to produce a 3.125 Hz sampling pulse, the Auto-Range Strobe. This countdown circuitry is made up of IC's 212, 207A, and 207B. The Strobe pulse is directed through an inverter, IC201D, to gates for the Auto-Range Counter. It enables these gates to pass count-up or countdown instructions from the Comparator to the Auto-Range Counter approximately 3 times per second. (See Sec. 4.13 on Comparators for the derivation of count-up/countdown instructions, and Sec. 4.14 on the Auto-Range Counter for response to these instructions.)

4.12 Logarithmic Analog/Digital Converter

In order for the Measuring Set to display a numerical count representing the dB level of an AC signal being measured, the AC signal is first converted to a DC Analog (See Sec. 4.9 on RMS AC/DC Converter) proportional to the RMS value of the AC signal. The DC Analog is then converted to a digital count proportional to the logarithm of the RMS level with respect to a fixed reference. Finally, the digital count is processed for conversion to a numerical count visible on the Display.

The change from DC Analog to digital count is performed by the Analog/Digital Converter. This process hinges on a characteristic of RC circuits: that the voltage-discharge rate of an RC circuit discharging toward ground follows an exponential curve with respect to time. It can be shown that the discharge time, T, between an initial charge level, V_i, and a final level, V_f, is proportional to the logarithm of the ratio of the two levels. First the exponential discharge curve is expressed as

$$V_f\ (t=T) = V_i\ (t=0)\ e^{-T/RC}$$

Converting this to

$$e^{-T/RC} = V_f/V_i$$

and solving for discharge time, T, gives

$$-RC\ \ln(V_f/V_i) = RC\ \ln(10)\ \log_{10}\ (V_i/V_f)$$

T may be expressed in dB if RC ln(10) = 20. If one of the two voltages, V_i or V_f, is a level being measured while the other is a fixed reference voltage, then T in dB will represent the level being measured with respect to the reference voltage.

In the Analog/Digital Converter, voltages V_i and V_f are applied to the inputs of a comparator circuit whose output is tied to the Counter. Each time the Counter cycles to an all-zero state (125 times per second), it begins a new count while the RC circuit, charged to V_i, begins to discharge. The Counter thus times the discharge of the RC circuit, until the RC voltage level, applied to one input of the comparator, equals the fixed voltage V_f at the other comparator input. At the instant both voltages are equal, the comparator signals

the Counter to stop, and the Counter's contents are dumped into a storage register. These contents represent discharge time T of the interval between V_i and V_f. Therefore, they may also be used to represent the level difference in dB between V_i and V_f, where one level is the DC Analog and the other is a reference.

The RC circuit is made up of R 55, R 56, and C 23. It is charged through IC4B and Q13, and its charge voltage is applied directly to one of the two inputs of comparator IC 6. The capacitor may be charged either to the DC Analog level or to a fixed reference voltage. Choice depends on sign of the dB value of the DC Analog.

For measurement of quantities expressed in positive dB, the RC circuit is charged to the DC Analog voltage, while the other input to comparator IC 6 is linked to the lower of the two Reference Supply voltages. For negative dB quantities, the RC circuit is charged to the higher Reference Supply voltage, and the DC Analog applied to the other input to IC 6. In either case, the charged RC circuit's voltage is designated V_i and applied to one input of IC 6. The other input to IC 6 is therefore V_f.

The discharge period, T, is initiated by each leading edge of the 125 Hz Output. At these instants, all Main Counter stages are at zero, the RC circuit has been fully charged, and Q13 is turned off. With the turn-off off Q13, the RC circuit begins to discharge toward ground, and the Main Counter begins a new count. The RC circuit discharges from its initial level, V_i, as seen by the positive input of comparator IC 6, until it reaches V_f, the level applied to the negative input of IC 6. When both inputs of IC6 are equal, its output goes positive. The circuits of IC206 respond through IC's 215A and B by interrupting the Main Counter. Subsequently, a Storage Strobe is developed to transfer contents of Main Counter IC's 220, 219, and 213A into Storage (the single bit content of IC213A is combined with the contents of the Automatic Attenuator Counter via IC's 217 and 218 to develop the most significant digit information for storage and display). Storage contents are directed to the L.E.D. Display through IC's 230, 229, and 228. Storage register IC227B contains sign information from the Sign Logic.

4.13 Comparators

Four Comparators, contained by IC's 3 and 5, generate up and down control signals for the Auto-Range Counter. Separate signals are needed for operation above and below 0 dBm and for dBrn, in order to provide overlapping ranges. A fifth Comparator, IC4A, hovers about the lower reference voltage (-1.897V) to establish the 0 dBm point and transfer sign information to the Sign Logic.

The four possible Comparator outputs are D+, D-, U+, and U-, where D=Down and U=Up. Down signals are derived from the -6.000 Volt reference by IC's 3A and 3B, while Up signals use the -1.897 reference and are generated at IC's 5A and 5B. Reference values of -6.000 and -1.897 volts were selected to represent a 10 dB spread, the range of each step of AC amplification. So that any DC Analog signal that falls within this range will give no Comparator output, while those outside will cause an Up or Down signal.

However, to provide a plus or minus 2 dB overlap in ranges, the reference levels are modified slightly by divider networks at their Comparator inputs. Approximate signal outputs are therefore as follows:

Output Signal	DC Analog Value
D-	-6.13 volts (approx)
D+	-7.55 volts (approx)
U-	-1.94 volts (approx)
U+	-1.507 volts (approx)

Thus, if the correct combination of AC attenuation and amplification is in effect for the AC signal being measured, the Measuring Set may be said to be "in range", and Comparator outputs will be zero. If the DC Analog is outside the ±10 dB reference range, the corresponding Comparator will signal the Auto-Range Counter to move up or down accordingly.

4.14 Auto-Range Counter

A four-bit, reversible, up/down counter controls the auto-ranging process with binary signals. The Counter is incremented up or down by instructions for the Comparators. Its four-bit count is issued to a decoding network which, in turn, selects drive relays to switch in the proper combination of attenuation and amplification for the AC signal being measured.

Counter elements are contained by IC208. Instructions from the Comparator are gated through IC's 203A and 203B. The resultant four bits of the output are labelled A, B, C, and D.

Of 16 possible Counter output states, only 11 are used, as shown in Table 4-A. To prevent the Counter from incrementing to any of the 5 illegal states, its input gate receives "go" or "inhibit" instructions from a limit decoder. The Limit Decoders are IC's 205A, 210A, 210B and 204B. Should the counter enter any illegal state for the type of measurement being made, additional logic senses this condition and immediately forces the counter into one of the legal states. This logic is contained in IC203C, IC204A, IC214B and IC239C.

Each increment of count is initiated by a strobe pulse issued 3.125 times per second by the Auto-Range Strobe. This rate has been established to allow sufficient stabilization periods for the relays and filters. The Strobe circuit includes IC's 212, 207A, 207B, and 201D. Its output is directed to the Counter input gates.

Note that various signals have thus far been mentioned as linked to the Counter's input gates. In all, three different signals are required. These are (1) an up/down instruction from the Comparators; (2) a go/inhibit instruction from the Limit Decoders; and (3) a strobe pulse from the Auto-Range Strobe.

Table 4-A shows the eleven usable, or legal, states of the Auto-Range Counter. Each is designated in both cardinal and binary numbers, and beside each is the corresponding input range and the corresponding combinations of AC attenuator and amplifier settings.

Auto-Range Counter State	dBm Range	dBrn Range	3/43 dB Attenuator	0/20 dB Amplifier State	10/20 dB Amplifier State	40 dB Amplifier State
ABCD						
0 (0000)	+10 → +22	-	43	0	10	0
1 (1000)	-2 → +12	-	43	0	20	0
2 (0100)	0 → -12	80 → 92	43	20	10	0
3 (1100)	-10 → -22	70 → 82	43	20	20	0
4 (0010)	-20 → -32	60 → 72	3	0	10	0
5 (1010)	-30 → -42	50 → 62	3	0	20	0
6 (0110)	-40 → -52	40 → 52	3	20	10	0
7 (1110)	-50 → -62	30 → 42	3	20	20	0
8 (0001)	-	20 → 32	3	0	10	40
9 (1001)	-	10 → 22	3	0	20	40
10 (0101)	-	0 → 12	3	20	10	40

TABLE 4-A

Auto-Range State vs. AC Attenuator & Amplifiers

4.15 Sign Logic

The sign is computed for each cycle of the A/D Converter from information provided by the Auto-Range Counter, the Comparators, and the Function Switches (S6). Correct sign signals are then sent to the A/D Converter, the Auto-Range Logic, and to Storage. Sign Logic is contained in IC's 227A, 222A, 222B, 222C, and 209F.

4.16 Display Logic and Storage

After each cycle of the A/D Converter, when the DC analog level has been translated into a count by IC's 213A, 219, and 220 of the Main Counter; a Storage strobe pulse is generated through IC's 215D, 215E, and 209E. This strobe enables transfer of the count into the Storage registers. The most significant digit of the display, however, is first processed through Display Logic IC218 using information from the Auto-Range Counter, the Function switch (S4), and the Sign Logic. This information is taken by Display Logic IC's 217A-217D and 214D. The Display Logic uses a four-bit full adder and 2's complement arithmetic. Its output is always a positive number for direct decoding, as the sign is developed separately by Sign Logic.

The Storage registers, IC's 223, 224, 225, and 227B provide drive to Display circuitry for a steady, no-flicker registration of count information, until the next Storage strobe pulse is generated. Strobe pulses occur 125 times per second.

4.17 BCD Output (816A-2)

Contents of the Storage registers are made available for external use, as well as the Measuring Set's Display, through a connector on the rear panel. Signal distribution among the connector pins is given in the chart below. These signals are taken from the inverted outputs of the Storage registers, then inverted by buffer circuits to become identical to their internal Display signal counterparts. From the buffers, the signals are routed directly to the rear-panel connector.

Since BCD outputs are taken from the Storage registers, they are updated at a 125 Hz rate, just as the internal display signals are. Updating may be held up, however, by holding Pin 22 of the BCD connector to a logical zero (ground). Pin 22 is referred to as the Display Update Inhibit Input; it is a buffered input appearing as a single DTL input with a 1000Ω resistor to the +5 volt supply. When this input is grounded, Storage latches are prevented from updating. During this "hold" condition, all other functions of the instrument, including blanking and auto-ranging, remain operative.

In addition to digit information, the BCD outputs also contain sign and blanking signals, and information to provide indication as to whether the Measuring Set is adjusted for dBm or dBrn measurements. Blanking and dBrn outputs are also buffered DTL outputs, derived from the Display blanking line and the MODE switch respectively.

BCD Connector Pin Signals

Pin No.	Signal	Bit
1	Ground	
2	Ground	
3	1 dB	B
4	1 dB	C
5	1 dB	D
6	1 dB	A
7	Blanking Signal	
8	.1 dB	B
9	.1 dB	C
10	10 dB	A
11	10 dB	B
12	+ Polarity	
13	dBrn Mode	
14	10 dB	C
15	10 dB	D
16		
17	.1 dB	A
18	.1 dB	D
19		
20		
21		
22	Display/Storage Update Inhibit Input	

CHAPTER 5

MAINTENANCE

5.1 Preliminary Note

It is most important that the recommendations and material in this chapter be studied prior to troubleshooting. Most of the Measuring Set's circuits are tied together or affected by feedback loops. Unless the feedback is disabled and the auto-ranging process simulated as directed, the isolation of problems will be extremely difficult if not impossible.

5.2 General

Determine the Measuring Set's operational status by conducting tests described in Section 5.3. If a need for calibration is indicated, refer to the procedures of Section 5.4. If malfunction is apparent, follow the directions of Section 5.5.

5.3 Performance Tests

WARNING: Be sure the Measuring Set's 115/230V Switch is set for proper line voltage before conducting any tests.

5.3.1 Bridging Impedance Check

a. Test Equipment Requirements

1.	50Ω Signal Generator	Krohn-Hite 4200 or Equiv.
2.	Detector	HP 400EL or Equiv.
3.	Resistor	RN60C1652F
4.	Coaxial Cable	Any type
5.	Twisted Cable Pair	12" maximum length

b. Test Setup

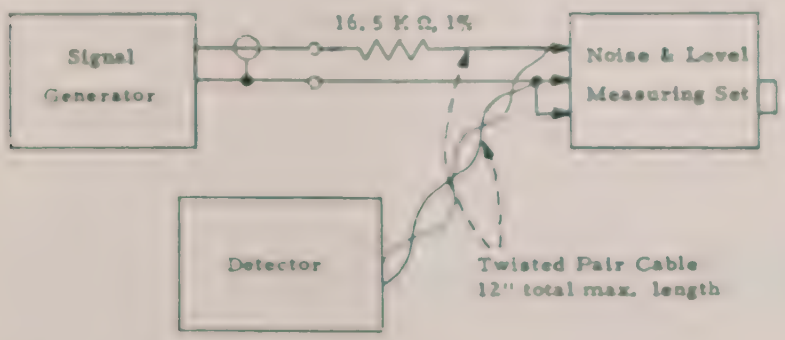


Figure 5.3.1A
Bridging Impedance Check

c. Procedure

1. With the measuring Set disconnected from the above Test Setup, adjust the Signal Generator for 1000 ± 100 Hz and a reading of 0 ± 0.1 dBm on the Detector. Depress the BRDG, 600Ω and dBm buttons on the front panel.
2. Apply power to the Measuring Set, then connect it to the Test Setup. The Detector reading should lie within 0 and -3 dBm.
3. Vary the Signal Generator output between frequencies of 300 Hz and 4000 Hz without changing amplitude. The Detector reading should remain within 0 and -3 dBm.

5.3.2 Terminating Impedance and Gain Compensation

a. Test Equipment Requirements

1. 600Ω Signal Generator (or 50Ω Signal Generator in series with 549Ω ±1% Resistor) - Bowmar/ALI 416A or Equiv.
2. 600Ω Attenuator — GR 1450-TB or Equiv.
3. Detector — HP 400EL or Equiv.
4. Coaxial Cable — Any type

b. Test Setup

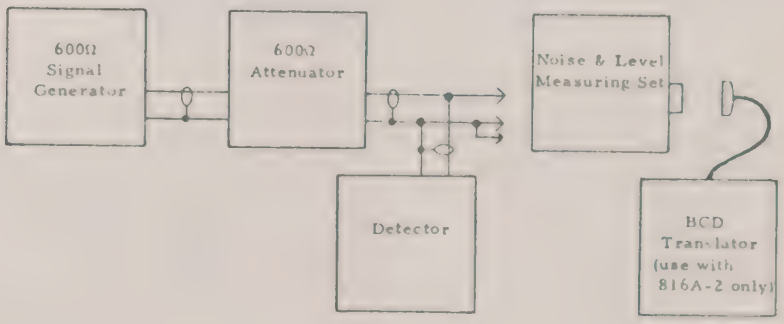


Figure 5.3.2A: Terminating Impedance and Gain Compensation

c. Procedure

1. With the Measuring Set disconnected from the above Test Setup, adjust the Signal Generator for a reading of 0 ± 0.1 dBm at 1000 ± 100 Hz on the Detector.

2. Apply power to the Measuring Set, then connect it to the Test Setup as shown.
3. Depress the TERM, dBm, and 600Ω buttons on the front panel of the Measuring Set. The Detector should read -6.0 ± 0.2 dBm, while the Measuring Set should read -6.0 ±0.3 dBm.
4. Depress the 135Ω button on the Measuring Set. The Detector should read -14.7 ± 0.2 dBm, while the Measuring Set should read -8.2 ±0.3 dBm.
5. Depress the 900Ω button on the Measuring Set. The Detector should read -4.4 ± 0.2dBm, while the Measuring Set should read -6.2 ±0.3 dBm.

5.3.3 Longitudinal Balance Test

a. Test Equipment Requirements

1.	600Ω Signal Generator (or 50Ω Signal Generator in series with 549Ω± 1% Resistor) - Bowmar/ALI 416A or Equiv.	
2.	Detector	HP 400EL or Equiv.
3.	Longitudinal Balance Test Fixture	Refer to schematic drawing of Fixture in Chapter 5-4.
4.	Coaxial Cable	Any type
5.	Shielded Twisted Pair Wire	Any type

b. Test Setup

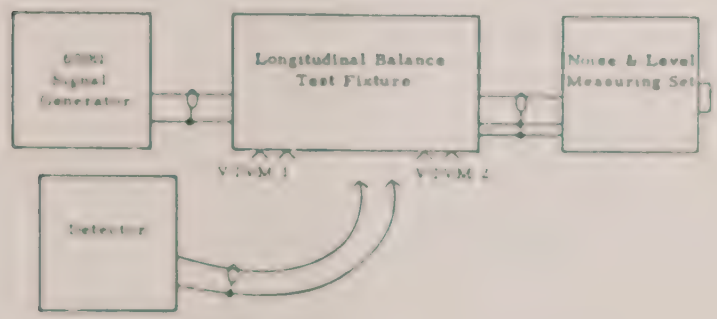


Figure 5.3.3A: Longitudinal Balance Test

c. Procedure

1. Connect the Detector to the VIVM 1 jacks, as shown, and apply power to all units.
2. Adjust the Signal Generator for a reading of 0 ± 0.1 dBm at 1000 ± 100 Hz on the Detector.

2. Tone Range

(A) Disconnect the AC Digital Voltmeter and vary the Attenuator through settings shown below. At each setting the Measuring Set should give the readings listed.

Att Setting	816A Reading	Att Setting	816A Reading
0 dB	+20.0 ± 0.1 dBm	26	-6.0 ± 0.1 dBm
5	+15.0 " "	27	-7.0 " "
8	+12.0 " "	28	-8.0 " "
9	+11.0 " "	29	-9.0 " "
10	+10.0 " "	30	-10.0 " "
11	+ 9.0 " "	31	-11.0 " "
12	+ 8.0 " "	32	-12.0 " "
13	+ 7.0 " "	33	-13.0 " "
14	+ 6.0 " "	35	-15.0 " "
15	+ 5.0 " "	45	-25.0 " "
16	+ 4.0 " "	55	-35.0 " "
17	+ 3.0 " "	65	-45.0 " "
18	+ 2.0 " "	75	-55.0 " "
19	+ 1.0 " "	80	-60.0 " "
20	± 0.0 " "		
20.1	- 0.1 " "		
20.2	- 0.2 " "		
20.3	- 0.3 " "		
20.4	- 0.4 " "		
20.5	- 0.5 " "		
20.6	- 0.6 " "		
20.7	- 0.7 " "		
20.8	- 0.8 " "		
20.9	- 0.9 " "		
21	- 1.0 " "		
22	- 2.0 " "		
23	- 3.0 " "		
24	- 4.0 " "		
25	- 5.0 " "		

3. Noise Range

(A) Depress the dBrnC button on the Measuring Set and vary the Attenuator through the readings listed below. The Measuring Set should give the readings shown for each Attenuator setting.

Att Setting	816A Reading
110 dB	+ with no numerals showing, +0 or +1 dBrnC
109	+1 ± 1 dBrnC
105	+5 ± 1 dBrnC
95	+15 " "
85	+25 " "

Att Setting	816A Reading	
75	+35 " "	
65	+45 " "	
55	+55 " "	
45	+65 " "	
35	+75 " "	
25	+85 " "	
20	+90 " "	
19	+91 " "	
18	+92 " "	or + with no numerals showing

(B) On the 816A-1 only, depress the dBrn 3 KHz button on the Measuring Set and vary the Attenuator through the reading listed below. The Measuring Set should give the readings shown for each Attenuator setting.

Att Setting	816A Reading	
90	+20 ±1 dBrn	
85	+25 " "	
75	+35 " "	
65	+45 " "	
55	+55 " "	
45	+65 " "	
35	+75 " "	
25	+85 " "	
20	+90 " "	
19	+91 " "	
18	+92 " "	or + with no numerals showing

4. Frequency Response (dBm Mode)
   (A) Depress the dBm button on the Measuring Set, and set the Attenuator to 25 dB.
   (B) Vary the frequency from 300 to 4000 Hz. The reading on the Measuring Set shall not vary more than ±0. 1 dB from the reading at 1000 Hz.
   (C) Change the Attenuator setting to 45 dB and repeat Step (B). The Measuring Set should indicate as shown in Step (B).

5. Frequency Response (dBrnC Mode)
   (A) Depress the dBrnC button on the Measuring Set and set the Attenuator to 25 dB.
   (B) Vary the frequency through the settings listed below. The Measuring Set should give the readings shown for each frequency.

Frequency (±1 Hz)	816A Reading
500	76 to 79 dBrn
600	79 to 82
700	81 to 84
800	82 to 85
900	83 to 86
1000	84 to 86
1200	83 to 86
1300	83 to 86
1500	83 to 85
1800	82 to 85
2000	82 to 85
2500	82 to 85
2800	82 to 85
3000	81 to 84
3300	77 to 82
3500	75 to 80

6. Frequency Response (dBrn 3 KHz Mode) - 816A-1 only
   (A) Depress the dBrn 3 KHz button on the Measuring Set with the Attenuator setting remaining at 25 dB.
   (B) Vary the frequency through the settings listed below. The Measuring Set should give the readings shown for each frequency or frequency range.

Frequency Range Hz	816A Reading
100 to 2200	84 to 86 dBrn

Frequency (±1 Hz)	816A Reading
2500	83 to 86 dBrn
2700	81 to 84
3000	81 to 83
3200	78 to 81
3500	77 to 80
3700	76 to 78

7. Display/Storage Up-Date Inhibit Input (816A-2 only)
   (A) Note the reading on both the BCD Translator and the 816A-2 under test. Depress and hold the HOLD button on the BCD Translator.
   (B) Change the Attenuator setting by one or several dB. Both the BCD Translator Display and the Measuring Set Display should hold the reading noted in (A) above.
   (C) Release the HOLD button. The Displays should change to the correct reading as determined by the Attenuator settings of (B) above.

5.4 Calibration

5.4.1 Test Equipment Requirements

a.	Voltmeter	Triplett, Simpson, or Digital Voltmeter listed below
b.	AC/DC Digital Voltmeter	Data Precision Model 2440 or Equiv.
c.	Oscilloscope	Tektronix Model 545 with 1A1 Plug-in or Equiv.
d.	Signal Generator	Krohn-Hite 4200 or Equiv.
e.	Attenuator	GR 1450-TB or Equiv.
f.	Detector	HP 400EL or Equiv.
g.	Frequency Counter	Monsanto 100B or GR 1192 or Equiv.
h.	Coaxial Cable	Any type
i.	Shielded Twisted Pair Wire	Any type

5.4.2 Procedures

5.4.2.1 Power Supply

Check the power supply voltages with respect to chassis ground at the three test points on the power supply board.

Voltages should be:

a.	+12.7	±1.0 Volts
b.	-12.7	±1.0 Volts
c.	+ 5.0	±0.5 Volts

5.4.2.2 Reference Supply Adjustment

a. Connect the Digital Voltmeter between TP303 and Ground (chassis), and set for DC measurement.
b. Adjust the Hi-Ref. potentiometer (R82) for -6.000 ± 0.005 volts.
c. Connect the Digital Voltmeter between TP304 and Ground (chassis), and retain the setting for DC measurement.
d. Adjust the Lo-Ref. potentiometer (R86) for -1.897 ± 0.005 volts.

5.4.2.3 Front-End Balance

a. Place the Measuring Set's BRDG/TERM Switch in its TERM position.
b. Short both input terminals together, but do not ground.
c. Apply an AC signal of between 2 and 5 volts at 1000 Hz between the input terminals and ground.
d. Connect the Oscilloscope between TP1 and Ground (chassis) and adjust the CMR ADJ potentiometer (R27) for an AC null.

5.4.2.4 A/D Converter Adjustment

Momentarily turn off the Measuring Set's power. On the logic board, remove the jumper wire from terminals E1 and E2 (if present) and place it between terminals E1 and E3. If a jumper wire is not present, install a jumper wire or clip lead between terminals E1 and E3. Turn the Measuring Set's power on.

b. Remove any input from the Measuring Set and connect TP218, on the logic board, to Ground (chassis) with a clip lead. The Display should become active, with a reading of either -50.0 or -60.0 dBm, a default reading.

c. Use two additional clip leads to connect TP209 and TP211 to Ground (chassis). Both test points are located on the logic board.

d. Connect the Oscilloscope between TP307 and Ground (chassis) and adjust the BAL ADJ potentiometer (R50) for the point where the Oscilloscope trace just switches from -0.7 V to +0.7 V. Remove the Oscilloscope connection and the clip leads connected to TP209 and TP211.

e. Momentarily turn off the Measuring Set's power. Move the jumper wire from between terminals E1 and E3 to between terminals E1 and E4. Turn the Measuring Set's power on.

f. Adjust the A/D ADJ potentiometer (R56) for a reading of x0.0 on the Display. The x can be any digit, but will probably be a 6.

NOTE: Both reference Voltage Supplies must be accurately adjusted before attempting this Step.

g. Momentarily turn off the Measuring Set's power. Remove the jumper wire from terminals E1 and E4 and return it to the original location of E1 and E2. Remove the remaining clip lead. Turn on the Measuring Set's power.

5.4.2.5 AC/DC Converter Offset Adjustment

a. Disconnect any input from the Measuring Set and short both input terminals to the Ground terminal.

b. Connect either the Oscilloscope or the Digital Voltmeter between TP301 and Ground (chassis) for a DC measurement. The voltage at this test point will lie between +0.7 and -0.7 volts. If the Oscilloscope is used, the trace will indicate noise, as well as the voltage level.

c. Set the 1st Offset Adjustment potentiometer (R327) for a DC null at TP301, with the Digital Voltmeter connected between TP301 and Ground (chassis). If an oscilloscope is used, adjust for a noise signal which is symmetrical about zero volts.

d. Remove the voltmeter or oscilloscope from TP301 and connect the Digital Voltmeter between TP302 and Ground (chassis).

e. Connect the Signal Generator output to the input of the measuring set and adjust the generator for approximately -10 dBm at 1 KHz.

f. Using a clip lead, connect TP217 to Ground.

g. Adjust the Signal Generator output level for a reading of -6.000 ± 0.005 VDC on the Digital Voltmeter.

h. Reduce the Signal Generator output by a 10 dB step and adjust the 2ND OFFSET adjustment, located near TP302, for a reading of -1.897 ± 0.005 VDC on the Digital Voltmeter.

i. Repeat steps g and h until no further adjustments are required.

j. Disconnect the Digital Voltmeter and clip lead

5.4.2.6 Input Attenuator Frequency Compensation

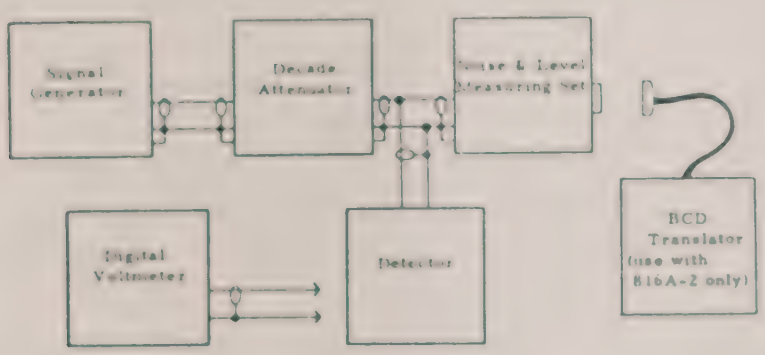


Figure 5.4.2.6: Input Attenuator Frequency Compensation

a. Depress the dBm, 600Ω, and TERM buttons on the front panel of the Measuring Set.

NOTE: The accuracy of Signal Generator adjustments to be made below may be improved by connecting a Digital Voltmeter to the DC output at the rear of the Detector, as shown in the diagram. However, results without the Digital Voltmeter are acceptable.

b. With the Attenuator set at 0 dB, adjust the Signal Generator for 1000 Hz and a level of 0.0 dBm as indicated on the Detector.

NOTE: The Measuring Set may not read 0 dBm since its gain has not yet been adjusted.

c. Disconnect the Detector from the input of the Measuring Set and reconnect to TP1 and Ground. Note the reading on the Detector.

d. Change the Signal Generator output to 110 KHz and recheck the level at the input of the Measuring Set for 0.0 dBm using the Detector as in step b.
e. Reconnect the Detector to TP1 as in step c and adjust capacitor C3 for the reading on the Detector noted in step c.
f. Repeat steps b through e until no further adjustments are necessary.
g. Increase the attenuator setting for an input of -30.0 dBm to the Measuring Set. Repeat steps b through f substituting -30.0 dBm for 0.0 dBm and C9 for C3.
h. Reverse the signal connection to the two upper terminals of the Measuring Set's input without disconnecting the lower ground terminal. In this connection, the upper most terminal and the ground terminal are now connected together and the signal is applied to the center terminal.
i. Repeat steps b through g substituting C6 for C3 and C10 for C9.
j. Repeat steps b through i until no further adjustments are necessary.
k. Disconnect the Detector from TP1 and reconnect it to the input of the Measuring Set.
l. Adjust the Attenuator and Signal Generator for 1 KHz and a reading of 0.0 dBm on the Measuring Set. Note the reading on the Detector.
m. Change the Signal Generator to 110 KHz and adjust the level for the reading on the Detector noted in step l above.
n. Adjust C55 for a reading of 0.0 dBm on the Measuring Set.
o. Check the frequency compensation at 20 KHz intervals from 10 KHz to 110 KHz using steps b, d, g, and i but without making further adjustments to the trimmer capacitors.

5.4.2.7 Gain Adjustments

NOTE: This procedure adjusts the overall gain of the Measuring Set. The Measuring Set should be checked and adjusted for Reference Supply output (Sect. 5.4.2.2), AC/DC Converter Offset (Sect. 5.4.2.5), and A/D Converter Adjustments (Sect. 5.4.2.4) before attempting the procedure of this section.

a. Connect a Signal Generator and the Digital Voltmeter to the Measuring Set's input terminals. Connect the Grounds of both test instruments to the Ground terminal of the Measuring Set. Connect the Frequency Counter to the Signal Generator output terminals in the same manner.
b. Select a combination of terminating impedance, AC voltage, and dBm from the chart below.

Impedance	AC Voltage	dBm
135Ω	0.3674	±0.00 dBm
600Ω	0.7746	±0.00 dBm
900Ω	0.9487	±0.00 dBm

c. Depress the TERM button of the BRDG/TERM switch, and the button of the 135/600/900Ω selector that corresponds to the combination chosen from the chart, on the Measuring Set's front panel. Also set the dBm button.

d. Adjust the Signal Generator for 1000 Hz ± 1 Hz at the voltage selected from the chart.

e. Adjust the GAIN ADJ potentiometer (R32) for the transition point between +0.0 and -0.0 dBm on the Measuring Set's Display.

f. Depress the dBrnC button on the Measuring Set's front panel.
NOTE: All other calibration adjustments, according to prior procedures, must have been made before attempting the following step.

g. Adjust the C-MESSAGE GAIN potentiometer (R150) for a Display reading of +90 dBrnC. Locate the potentiometer positions for readings of +89 and +91 dBrnC, and place the adjustment midway between these two points.

5.5 Troubleshooting

5.5.1 General

a. Localization. Familiarize yourself with the overall operation of the unit (Chapter 4). Once feedback is disabled, isolation of a malfunction will follow routine techniques. Several checkpoints, labelled and numbered as test points with "TP" designations, are provided in the logic sections. These test points are shown in the schematic diagrams of Chapter 6, and they are listed with pertinent signal data and useful information in the tables which follow.

b. Power Supply. Check for proper voltages under full load. They should be as follows:

+12V Supply	+11.5 to +13.9 Vdc	<10 mV ripple
-12V Supply	-11.5 to -13.9 Vdc	<10 mV ripple
+5V Supply	+ 4.6 to + 5.4 Vdc	<50 mV ripple

Refer to the schematic (Chapter 6) for circuit configurations. Access to measuring points is provided by test points located and appropriately labelled on the Analog Board. Measure between these points and ground (chassis) with any suitably accurate voltmeter.

c. Chassis Components. With primary power disconnected from the unit, check the resistance or continuity of any component suspected of being defective.

5.5.2 Isolation Guides & Recommendations

CAUTION: This equipment contains transistors, diodes, and other solid state components. Be extremely careful when measuring voltages to prevent short circuits. Use tape or sleeving to insulate the entire test prod except the outermost portion of the tip.

a. Unless otherwise specified, all troubleshooting shall be done in the dBm mode with the auto-ranging circuitry disabled. The dBm mode is attained by actuating the dBm Switch on the front panel. Auto-ranging circuitry is disabled by grounding Test point (TP) 214 to the chassis with a simple clip lead.

b. Disabling the auto-ranging circuitry places and holds the switchable AC attenuator and amplifiers in a fixed state. Any other states of the AC section, (as given in the range chart of Chapter 4) may then be set by energizing or de-energizing appropriate relays. Refer to the schematics of Chapter 6 for appropriate relays, or to the table below.

Individual relays are controlled through test points listed in the table. These test points are connected to the bases of the relay drivers. Shorting a test point to ground (chassis) de-energizes a relay, while connecting one of the +12V test points through a 47 KΩ to 150 KΩ resistor to a relay test point energizes the corresponding relay.

WARNING: Failure to use a current limiting resistor as specified will damage the relay driver.

Relay	Test Point	Circuit	Energized	De-energized
K1	TP11	3/43 dB Atten.	43 dB Atten.	3 dB Atten.
K2	TP12	two 20 dB Amps	20 + 20 dB gain	-
K3	TP13	0/20 dB Amp.	0 dB	20 dB
K4	TP14	10/20 dB Amp.	10 dB	20 dB
K5	TP15	C Message Filt.	C Message Filt.	-

TABLE 5-1

c. Use the schematics and component layout diagrams to trace signals, measure voltages, and monitor waveforms in isolating problems.

d. Semiconductors are more prone to failure than any other components. Check operation of transistors and IC's (Integrated Circuits) by seeing that they pass a signal.

e. The possibility of intermittent troubles should not be overlooked. If present, this fault may often be forced to materialize by tapping or jarring the equipment.

f. Clock and Counter outputs may be checked according to the following table.

Test Point	Approx Frequency	Duty Cycle
204	1 MHz	50% - square
205	500 KHz	50% - square
206	50 KHz	20%
207	5 KHz	20%
208	500 Hz	20%
209	250 Hz	50% - square
210	125 Hz	50% - square
211	125 Hz	50% - square
212	12.5 Hz	20%
213	3.125 Hz	50% - square

TABLE 5-2

g. The following table lists additional test points along with corresponding signals and useful checks.

Test Point	Purpose of Signal	Effects of Grounding
214	3.125 Hz Auto-Range Strobe	Locks auto-ranging circuitry, breaking feedback loop.
215	"1" calls for down count of auto-range circuit	Inhibits down count
216	"1" calls for up count of auto-range circuit	Inhibits up count
217	"0" forces Auto-Range Counter to legal state	Presets Auto-Range Counter to Hex 3 (-10 to -22 dBm).
218	"1" blanks display	Inhibits display blanking
201	"1" "0" when A/D conversion takes place	NA
202	NA	Lamp test: all eights on Display
203	Display latch strobe pulse	NA

TABLE 5-3

NOTES:

1. TP 214: After grounding this point, the Auto-Range circuitry may be stepped one range at a time by momentarily removing the short, provided the signal being measured warrants a change.

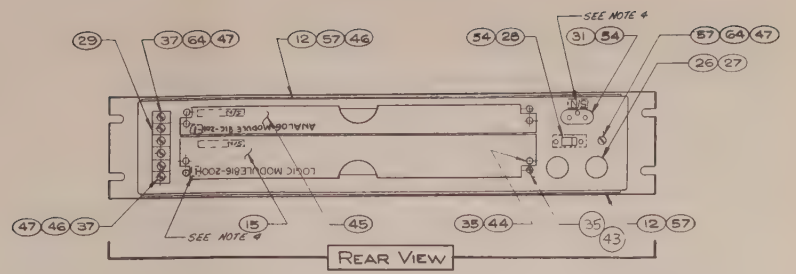
2. TP 217: Grounding this terminal forces the Auto-Range Counter to "hexidecimal 3" state, corresponding to the -10 to 22 dBm or +68 to +80 dBrn ranges.

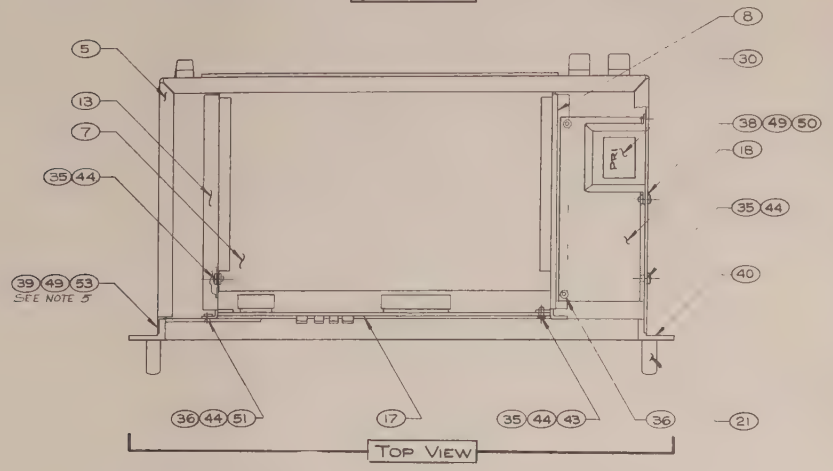
3. TP 218: Grounding this point prevents the Display from blanking when an out-of-range condition exists. Should the 20 dB range of the A/D Converter be exceeded, a meaningless number may be displayed.

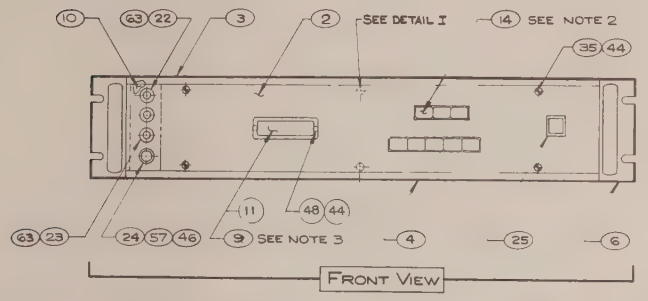
CHAPTER 6

DRAWINGS

D816-001-1	Assembly Wiring	
D816-001-2	Assembly Wiring	
D816-100	Logic Schematic	SH1
		SH2
		SH3
D816-101	Analog Schematic	SH1
		SH2
D816-102	Interconnection Diagram	
D816-103	Power Supply Schematic	
D816-105	External BCD Logic	
D816-200-1	Logic Module Assembly	
D816-200-2	Logic Module Assembly	
D816-201-1	Analog Module Assembly	SH1
		SH2
D816-201-2	Analog Module Assembly	
C816-202	Front Panel Module Assembly	
C816-203	Power Supply Assembly	
C816-205	3KHz Low Pass Filter Assembly	

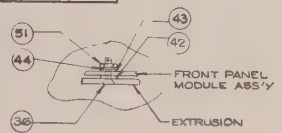






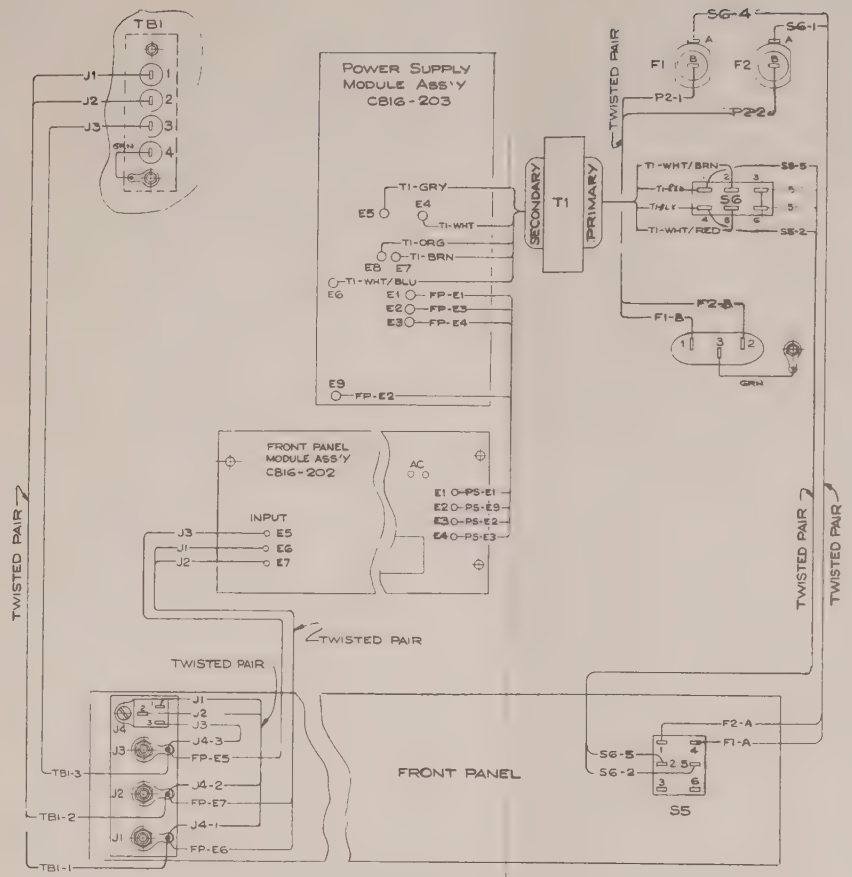
NOTES

1. FOR LIST OF MATERIALS : SEE LMDBIG-001-1
2. LOC-TITE KNOBS TO SWITCH SHAFT
3. EPOXY FILTER WINDOW IN RECESS OF BEZEL PANEL (404 LOCTITE)
4. HANDSTAMP 1/8" HIGH BLACK UPPER CASE CHARACTERS, DASH 1 ON LOGIC & ANALOG MODULES SERIAL NO. 5 ON WRAPAROUND, ANALOG & LOGIC MODULES
5. ROLL PIN (ITEM 53) MUST BE MIN. .002 BELOW FLUSH WITH SURFACE OF ITEM 40



DETAIL I
TYPICAL (2)

MECHANICAL
ELECTRICAL

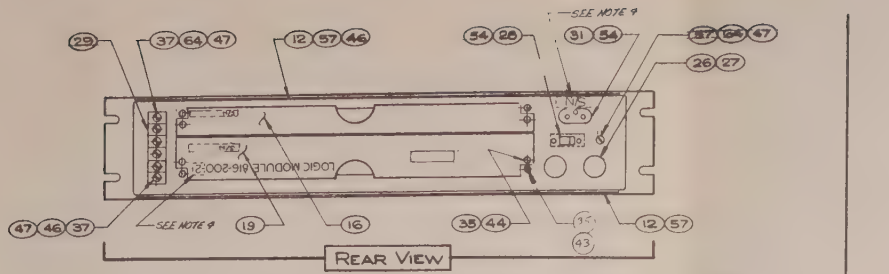


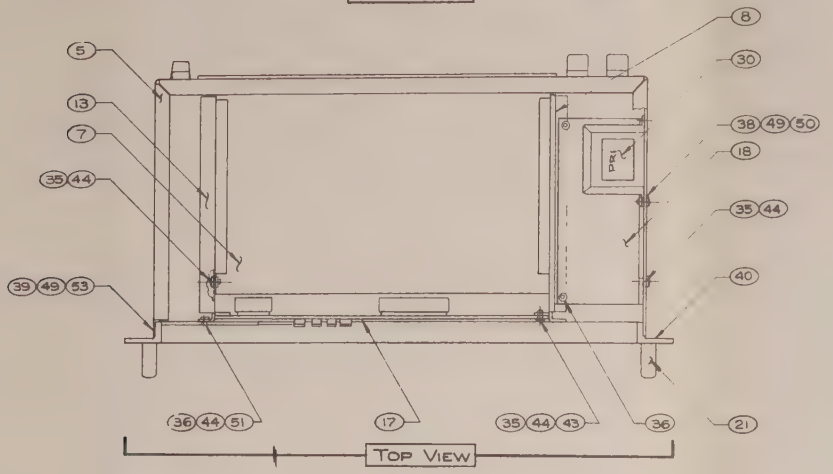
NOTES

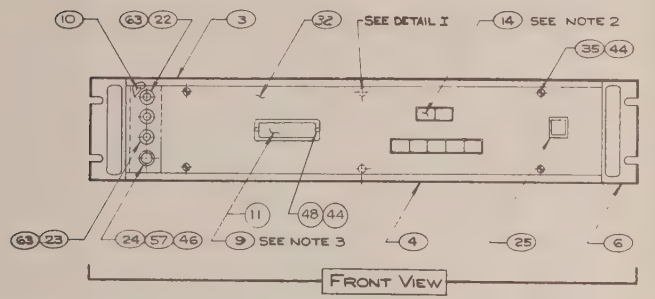
4. FOR WIRE RUN LIST : SEE A816-110G
5. UNLESS OTHERWISE SPECIFIED : ALL WIRES #22AWG. STRANDED

Assembly Wiring

D816-001-1



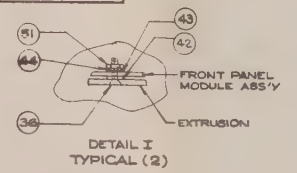




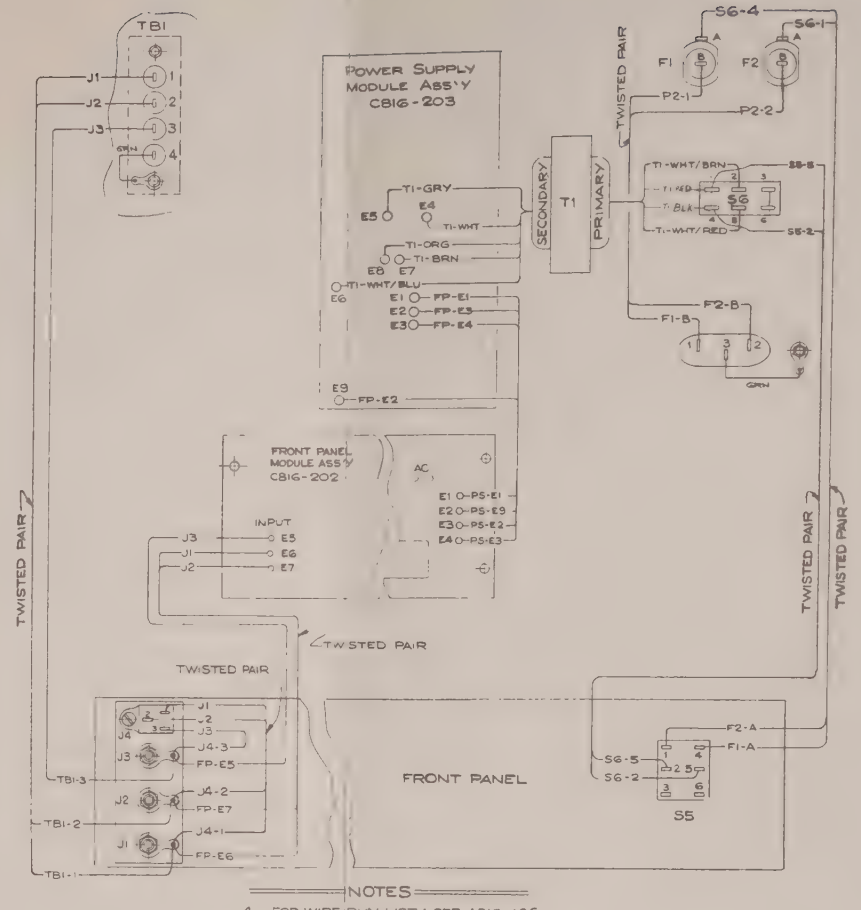
MECHANICAL
ELECTRICAL

NOTES

1. FOR LIST OF MATERIALS : SEE LMD816-001-2
2. LOC-TITE KNOBS TO SWITCH SHAFT
3. EPOXY FILTER WINDOW IN RECESS OF BEZEL PANEL (404 LOCTITE)
4. HANDSTAMP 1/8 HIGH BLACK, UPPER CASE CHARACTERS, DASH 2 ON LOGIC MODULE, & SERIAL NOS. ON WIRAROUND, ANALOG & LOGIC MODULE



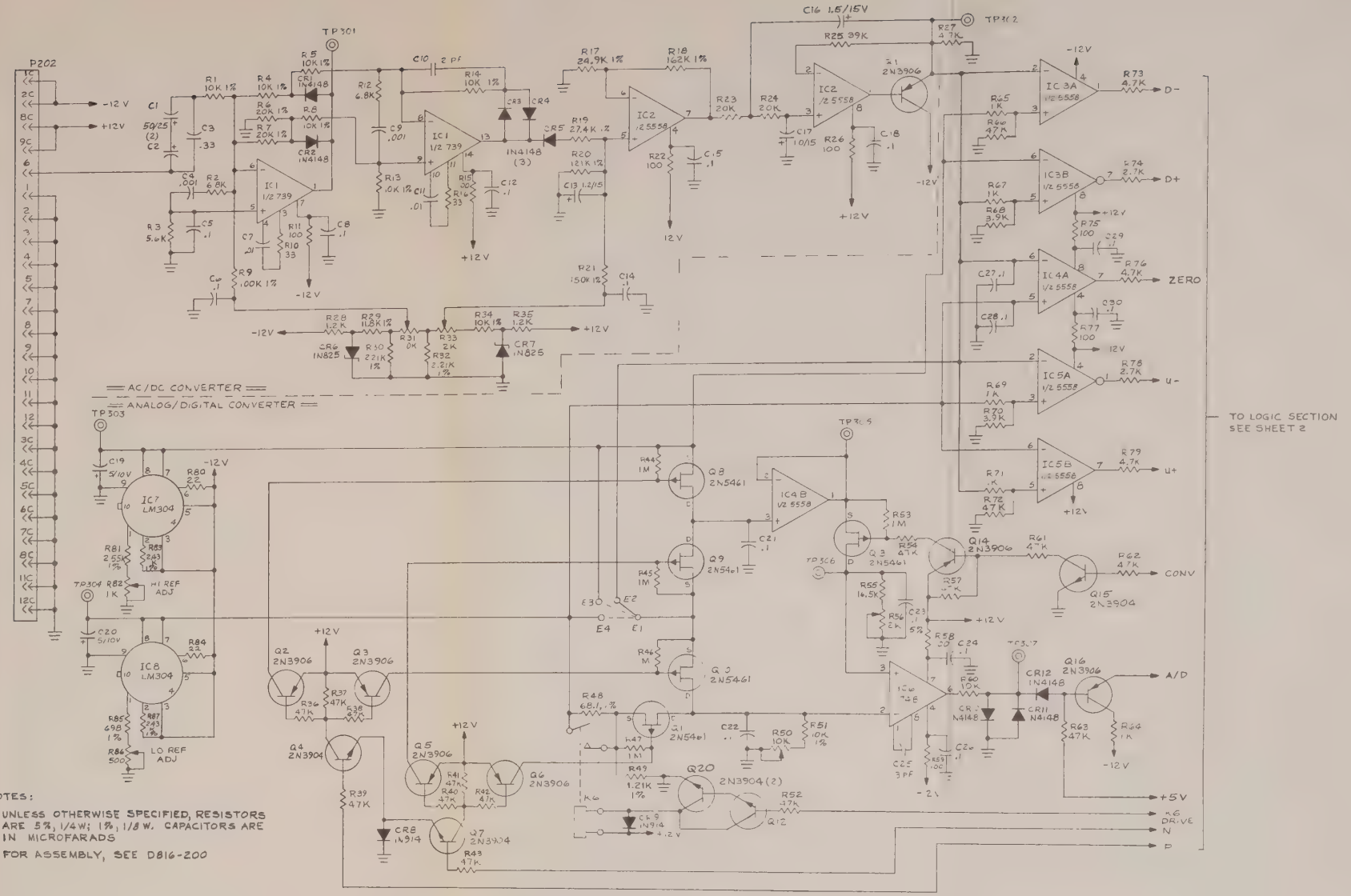
DETAIL I
TYPICAL (2)



NOTES

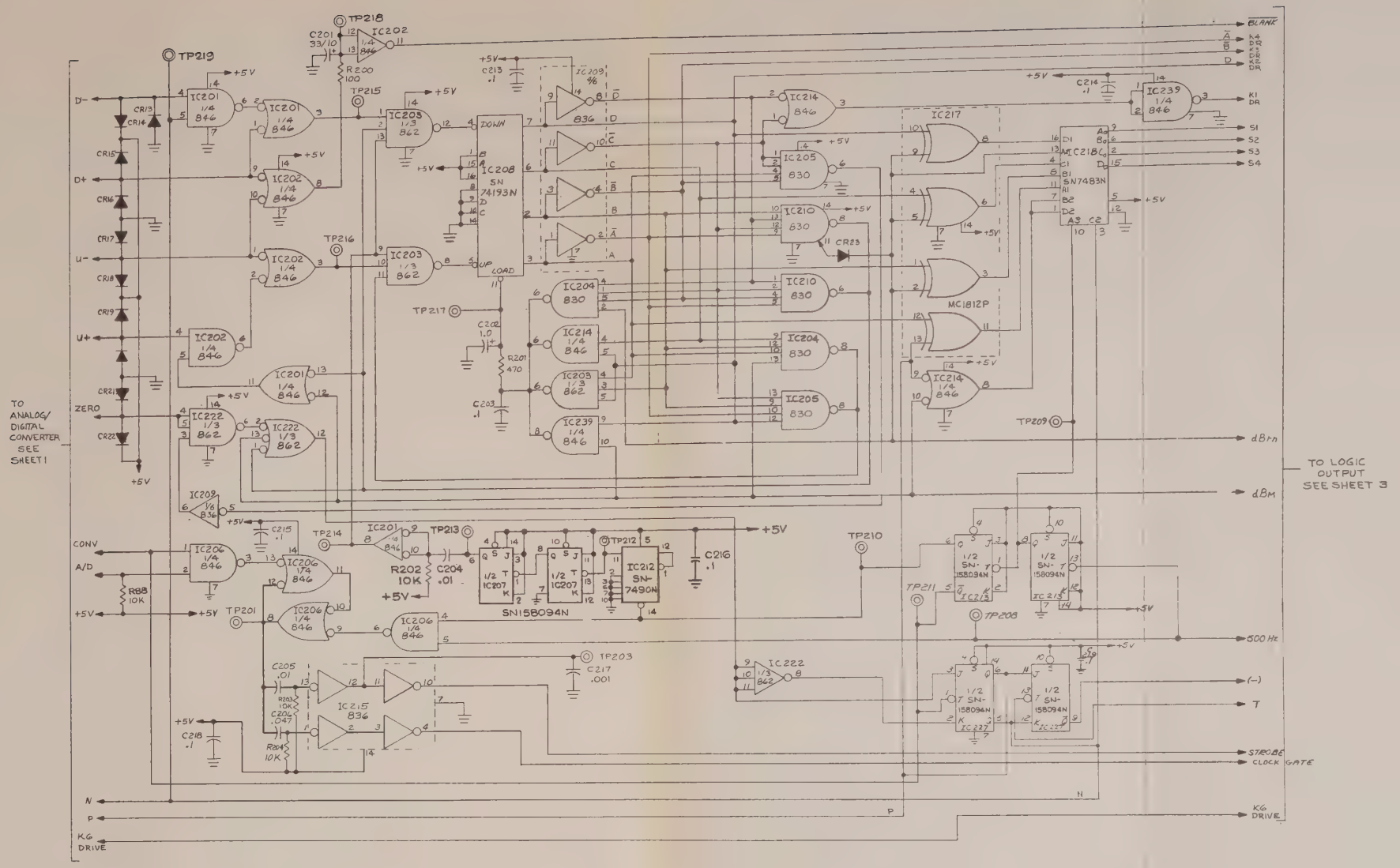
4. FOR WIRE RUN LIST : SEE A816-106
5. UNLESS OTHERWISE SPECIFIED : ALL WIRES #22AWG. STRANDED

Assembly Wiring
D816-001-2


AC/DC CONVERTER
ANALOG/DIGITAL CONVERTER
TO LOGIC SECTION SEE SHEET 2
NOTES:
1. UNLESS OTHERWISE SPECIFIED, RESISTORS ARE 5%, 1/4W; 1%, 1/8 W. CAPACITORS ARE IN MICROFARADS
2. FOR ASSEMBLY, SEE D816-200

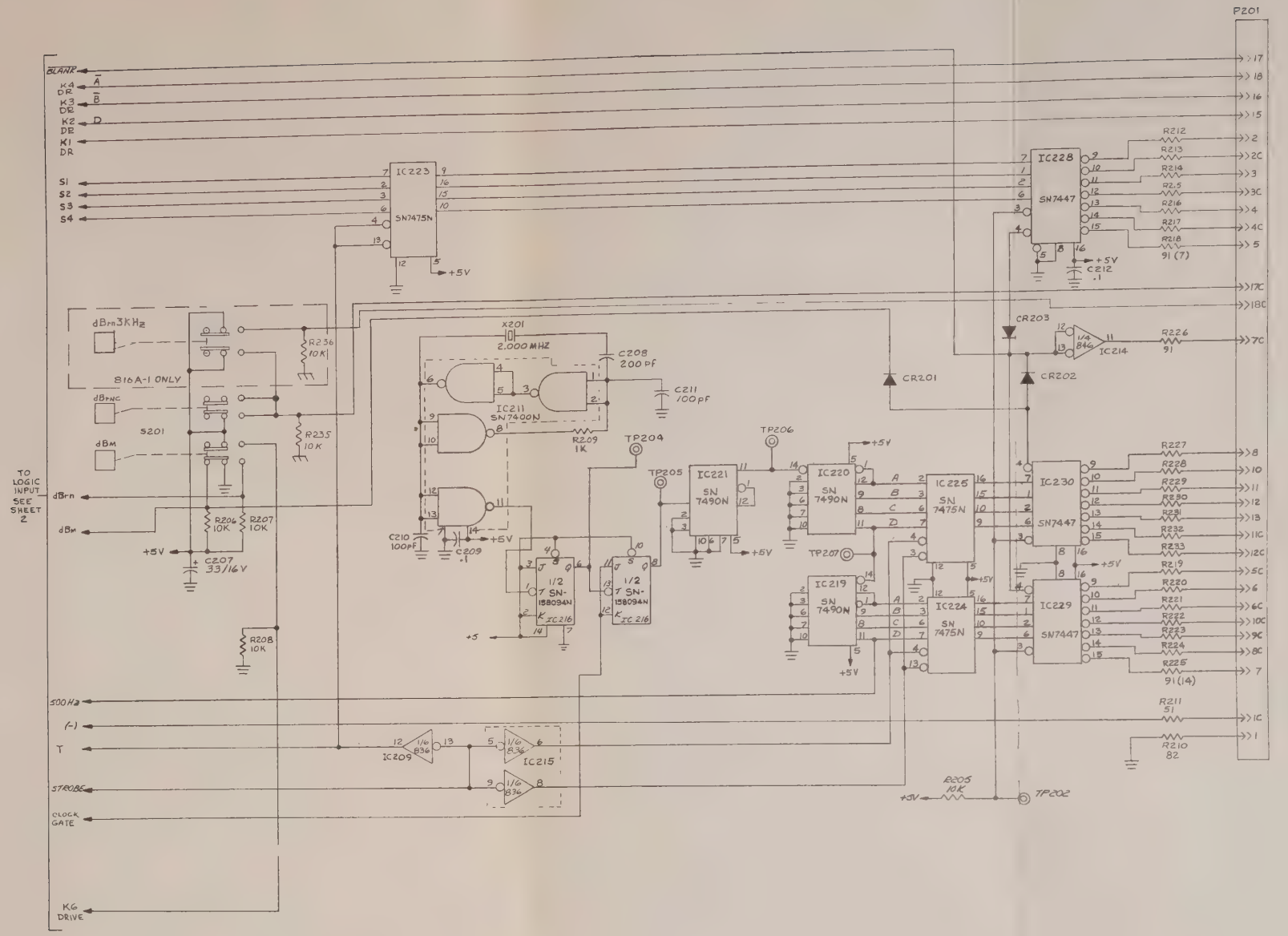
Logic Schematic

D816-100 Sheet 1



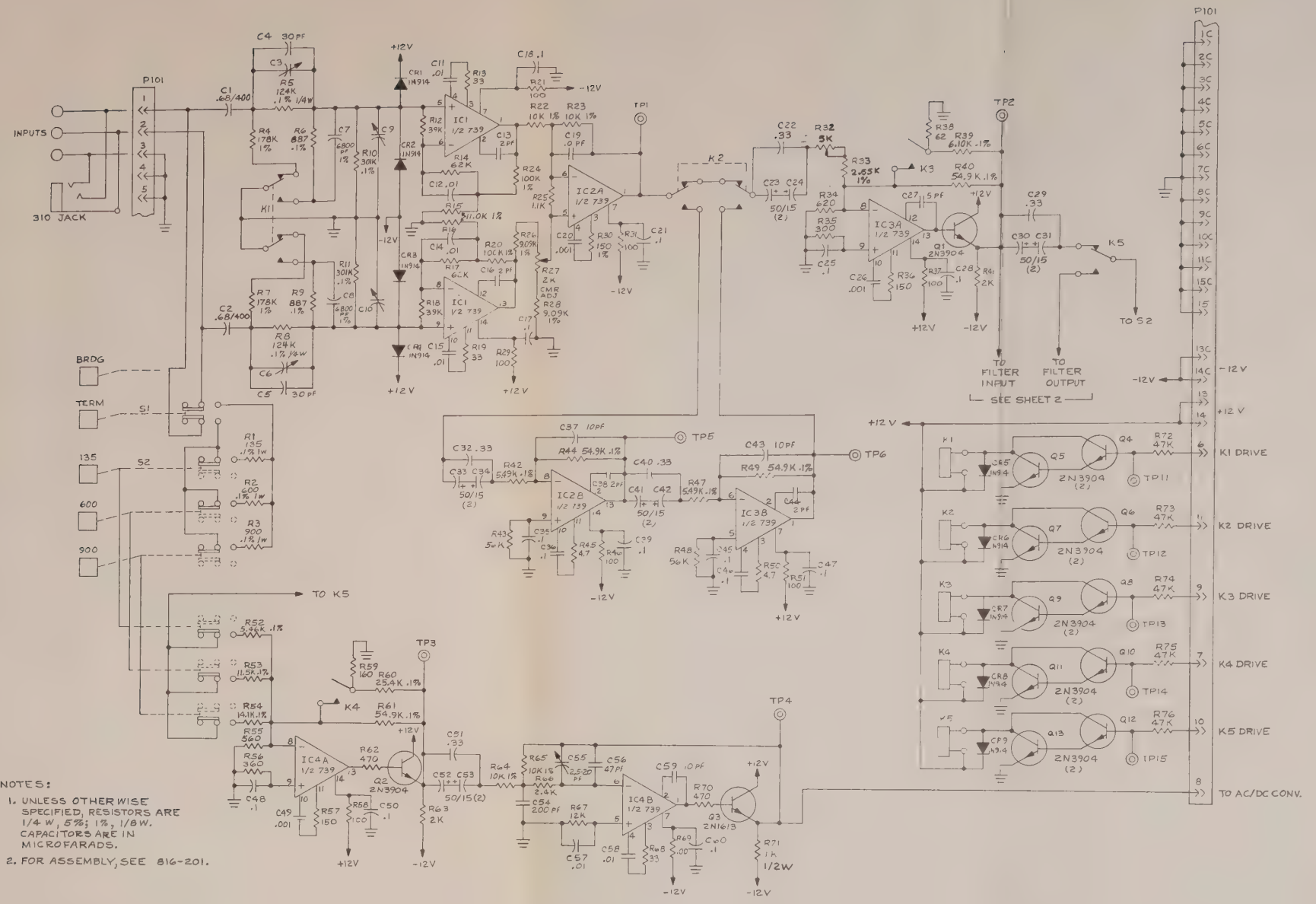
Logic Schematic

D816-100 Sheet 2



Logic Schematic

D816-100 Sheet 3

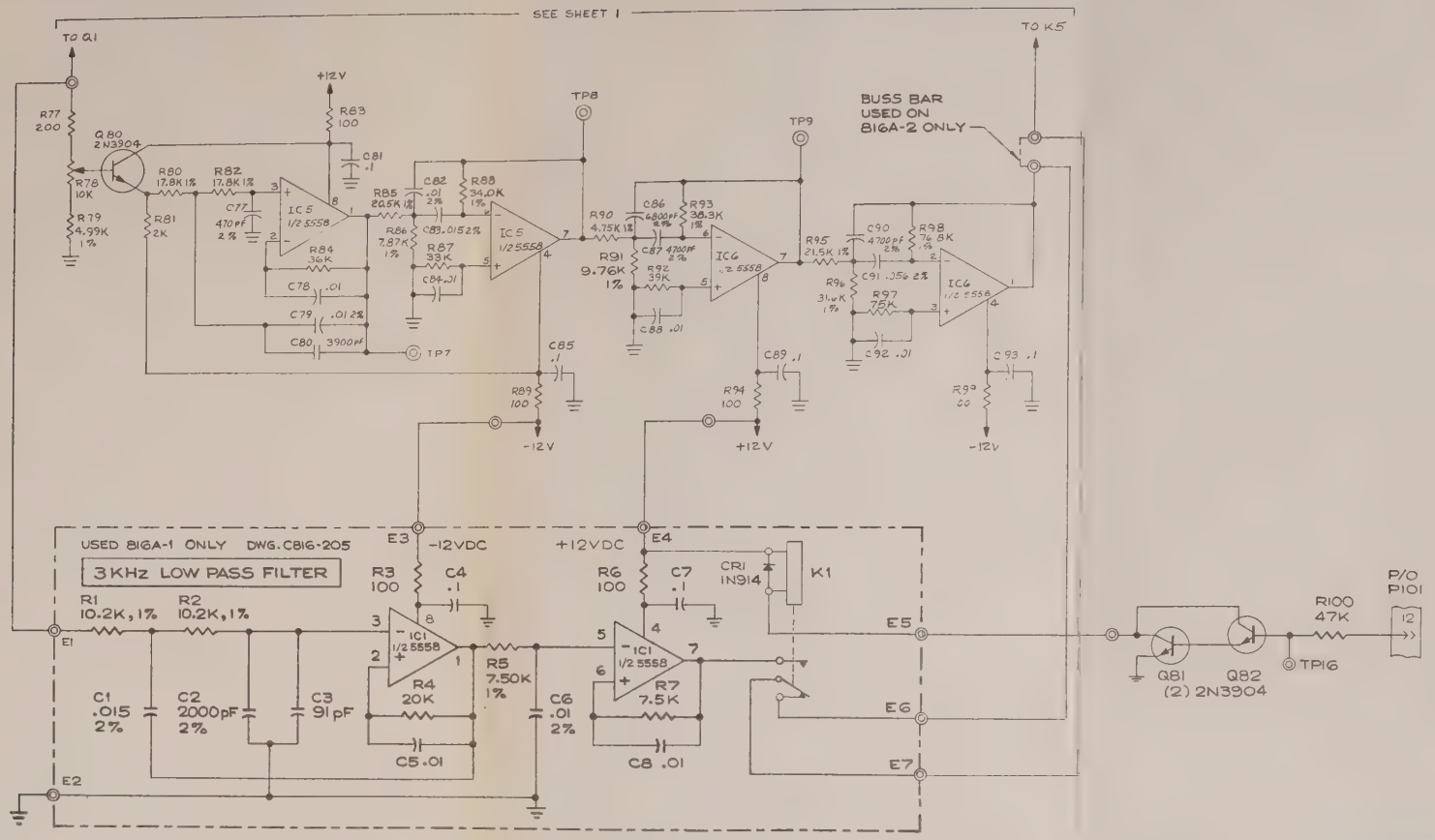


NOTES:

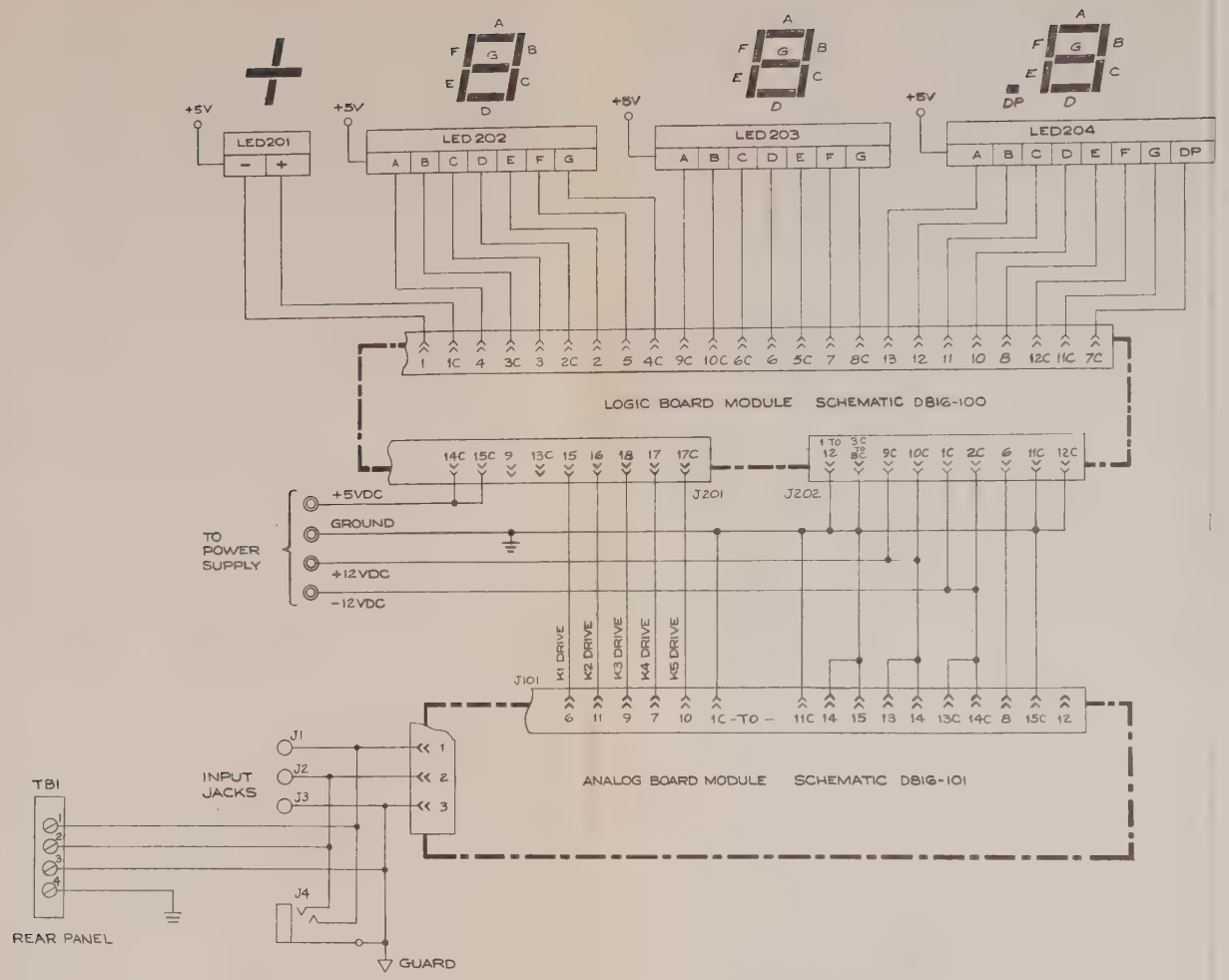
1. UNLESS OTHERWISE SPECIFIED, RESISTORS ARE 1/4 W, 5%; 1%, 1/8W. CAPACITORS ARE IN MICROFARADS.
2. FOR ASSEMBLY, SEE 816-201.

Analog Schematic

D816-101 Sheet 1



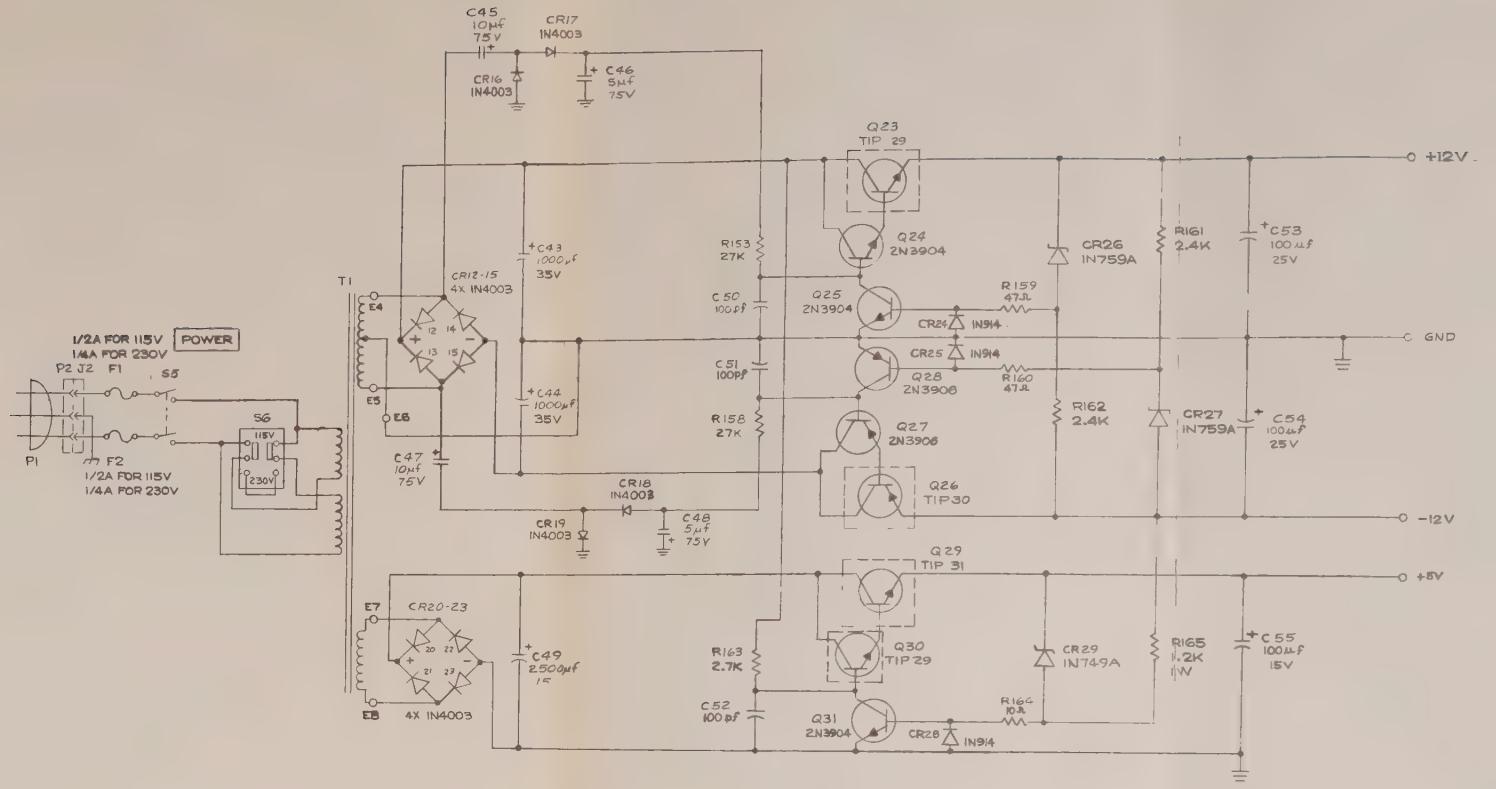
Analog Schematic
D816-101 Sheet 2



Notes

1. FOR ASSEMBLY DRAWING SEE C816-202

Interconnection Diagram
D816-102



NOTES

1. FOR ASSEMBLY DRAWING SEE D8IGA-202
2. UNLESS OTHERWISE SPECIFIED RESISTORS ARE 1/2W, 5%

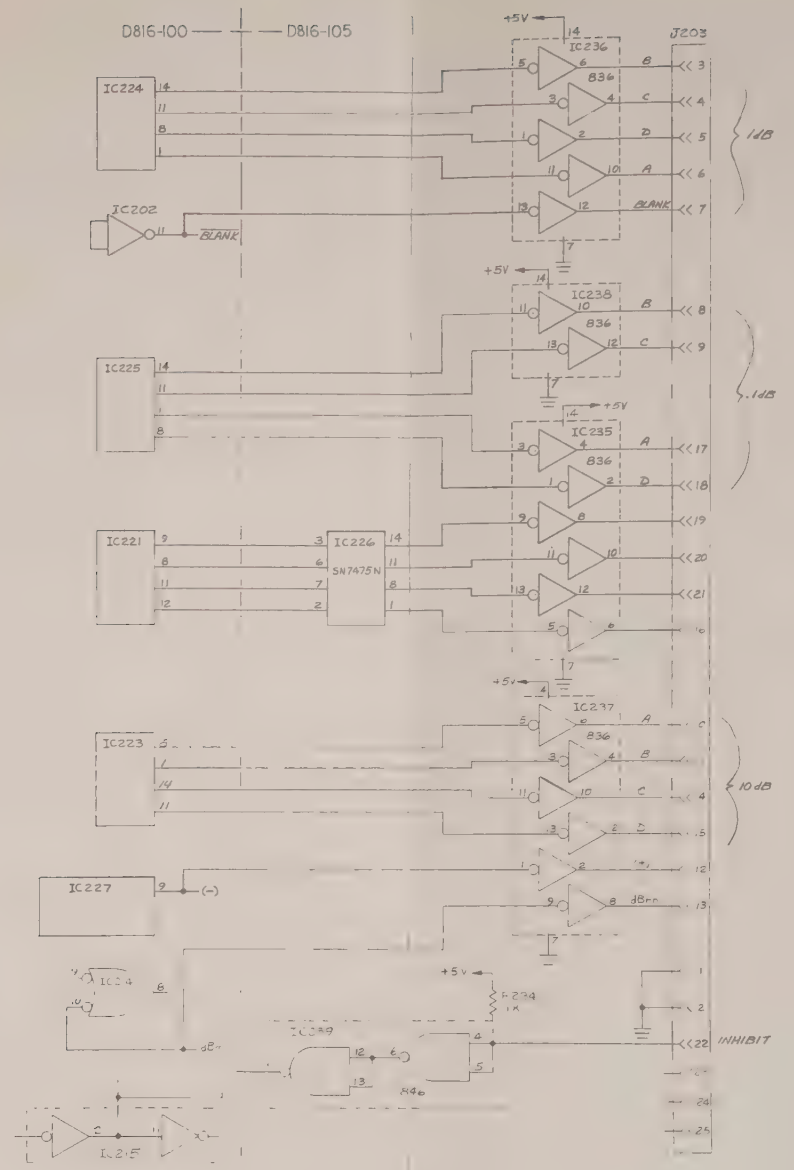
Power Supply Schematic

D816-103

NOTES:

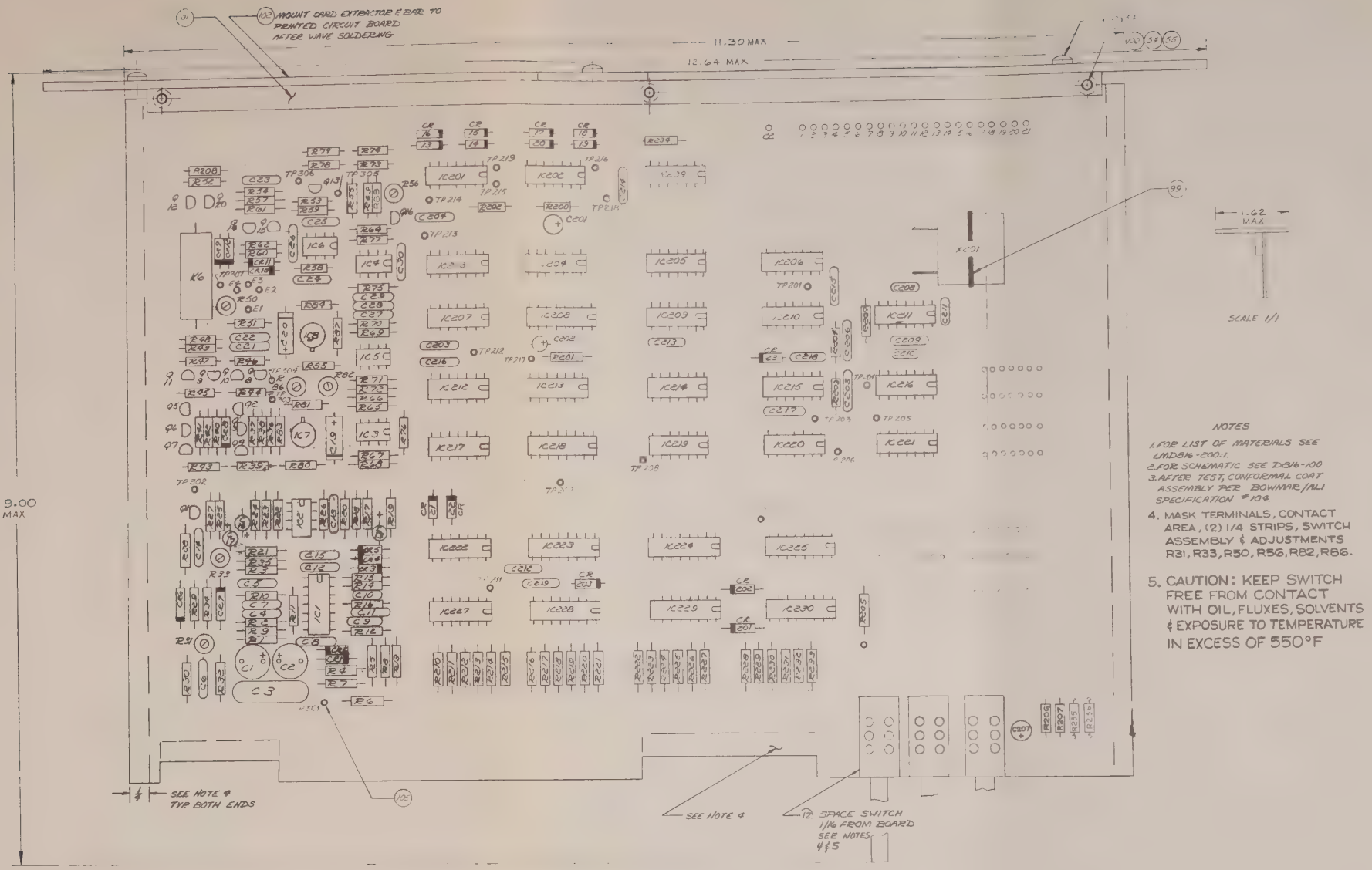
1. THIS SCHEMATIC COMPLETES THE REQUIREMENTS OF D816-100 (816A-1) CIRCUITS FOR 816A-2 DIGITAL LEVEL MEASURING SET.

2. UNLESS OTHERWISE SPECIFIED, RESISTORS ARE 1/4, 5%



External BCD Logic

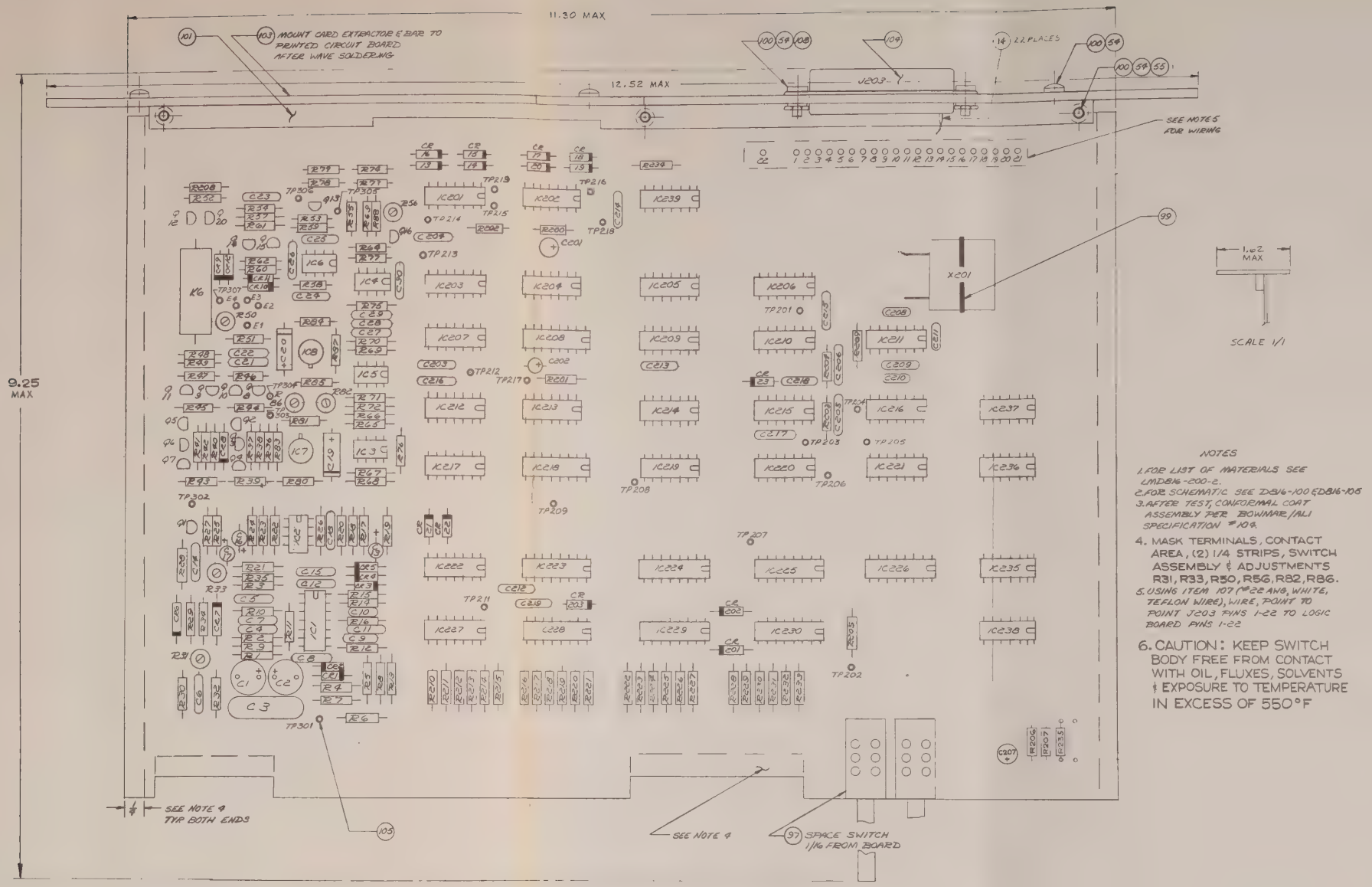
D816-105


MOUNT CARD EXTRACTOR & BAR TO PRINTED CIRCUIT BOARD AFTER WAVE SOLDERING
11.30 MAX
12.64 MAX
9.00 MAX
1.62 MAX
SCALE 1/1
SEE NOTE 4 TYP BOTH ENDS
SEE NOTE 4
SPACE SWITCH 1/16 FROM BOARD SEE NOTES 4 & 5

NOTES

1. FOR LIST OF MATERIALS SEE LMD816-200-1.
2. FOR SCHEMATIC SEE D816-100
3. AFTER TEST, CONFORMAL COAT ASSEMBLY PER BOWMAR/ALI SPECIFICATION #104.
4. MASK TERMINALS, CONTACT AREA, (2) 1/4 STRIPS, SWITCH ASSEMBLY & ADJUSTMENTS R31, R33, R50, R56, R82, R86.
5. CAUTION: KEEP SWITCH FREE FROM CONTACT WITH OIL, FLUXES, SOLVENTS & EXPOSURE TO TEMPERATURE IN EXCESS OF 550°F

Logic Module Assembly
D816-200-1

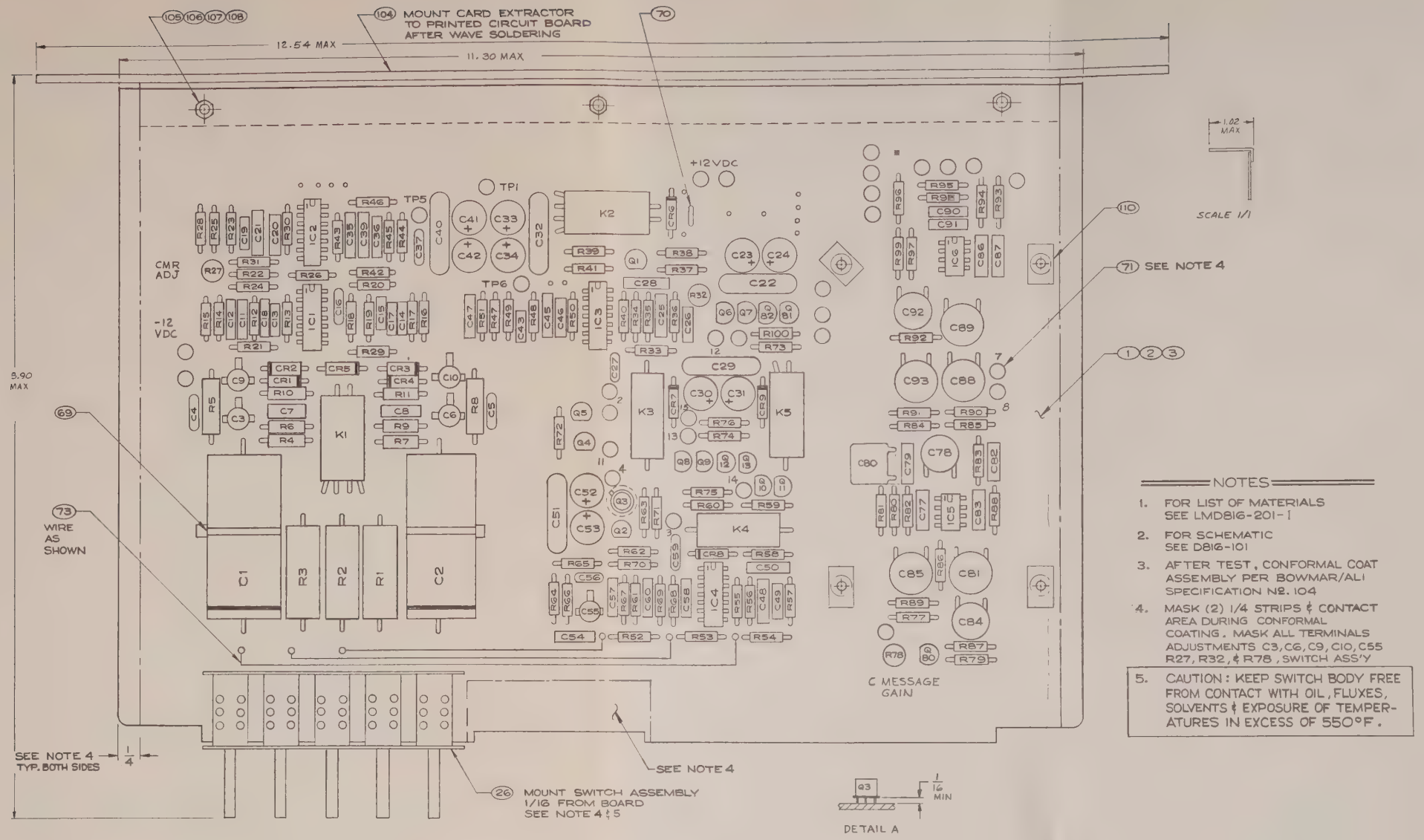


NOTES

1. FOR LIST OF MATERIALS SEE LMD816-200-2.
2. FOR SCHEMATIC SEE D816-100 & D816-105
3. AFTER TEST, CONFORMAL COAT ASSEMBLY PER BOWMAR/ALI SPECIFICATION #104.
4. MASK TERMINALS, CONTACT AREA, (2) 1/4 STRIPS, SWITCH ASSEMBLY & ADJUSTMENTS R31, R33, R50, R56, R82, R86.
5. USING ITEM 107 (#22 AWG, WHITE, TEFLON WIRE), WIRE, POINT TO POINT J203 PINS 1-22 TO LOGIC BOARD PINS 1-22
6. CAUTION: KEEP SWITCH BODY FREE FROM CONTACT WITH OIL, FLUXES, SOLVENTS & EXPOSURE TO TEMPERATURE IN EXCESS OF 550°F

Logic Module Assembly

D816-200-2

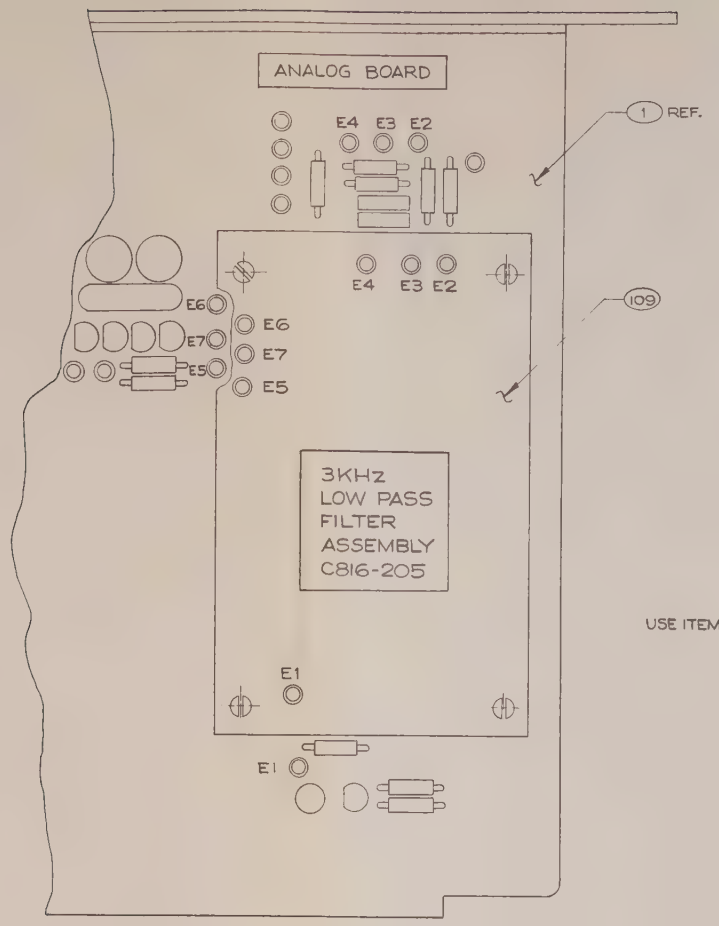


NOTES

1. FOR LIST OF MATERIALS SEE LMD816-201-1
2. FOR SCHEMATIC SEE D816-101
3. AFTER TEST, CONFORMAL COAT ASSEMBLY PER BOWMAR/ALI SPECIFICATION NO. 104
4. MASK (2) 1/4 STRIPS & CONTACT AREA DURING CONFORMAL COATING. MASK ALL TERMINALS ADJUSTMENTS C3, C6, C9, C10, C55 R27, R32, & R78, SWITCH ASS'Y
5. CAUTION: KEEP SWITCH BODY FREE FROM CONTACT WITH OIL, FLUXES, SOLVENTS & EXPOSURE OF TEMPERATURES IN EXCESS OF 550°F.

Analog Module Assembly

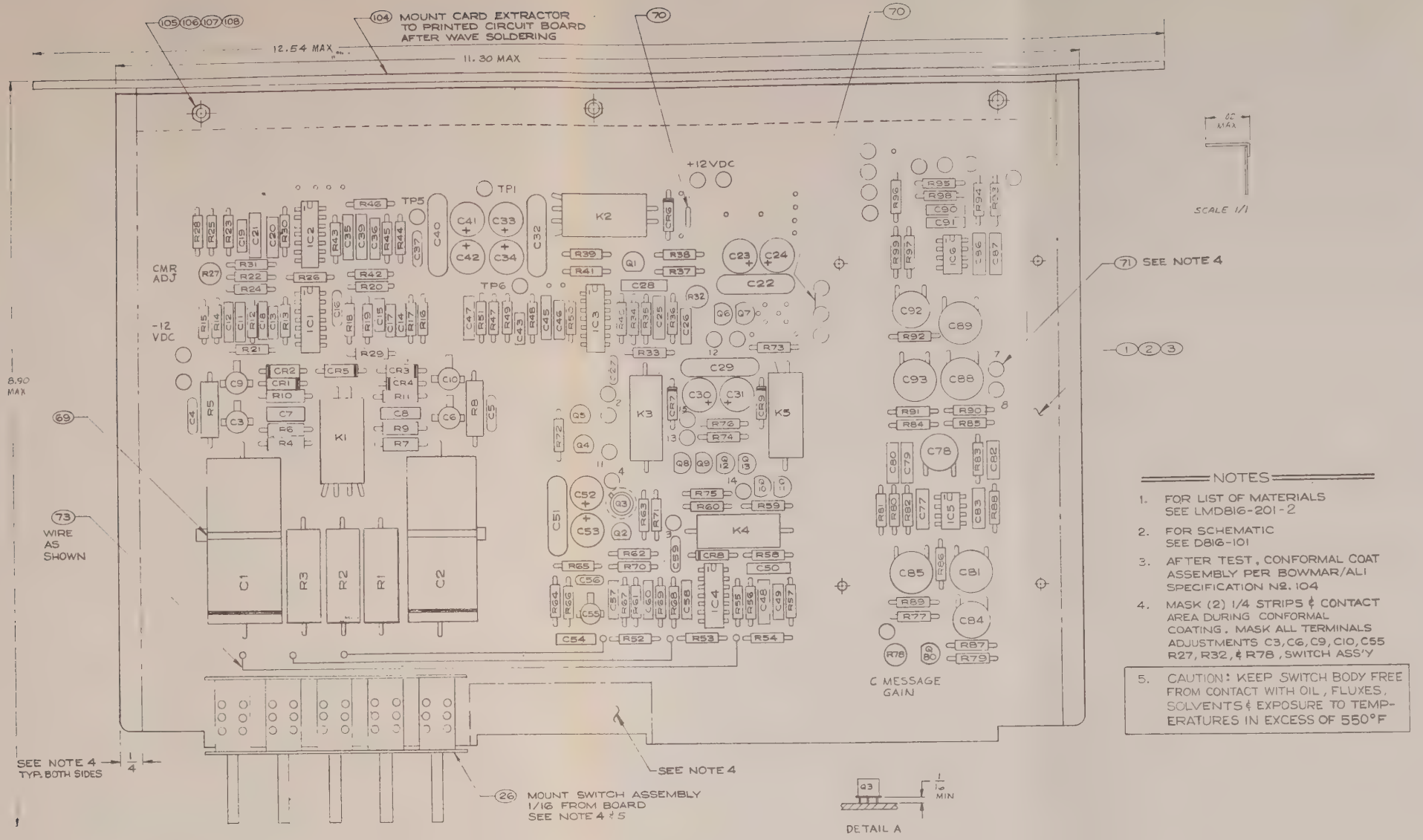
D816-201-1 Sheet 1



USE ITEM 73

POINT TO POINT WIRING		
ANALOG BOARD	FILTER BOARD	FUNCTION
E1	E1	INPUT
E2	E2	GROUND
E3	E3	-12VDC
E4	E4	+12VDC
E5	E5	DRIVER
E6	E6	FILTER OUTPUT
E7	E7	TO K6 ANALOG BOARD

FOR LIST OF MATERIALS
SEE LMD816-201-1

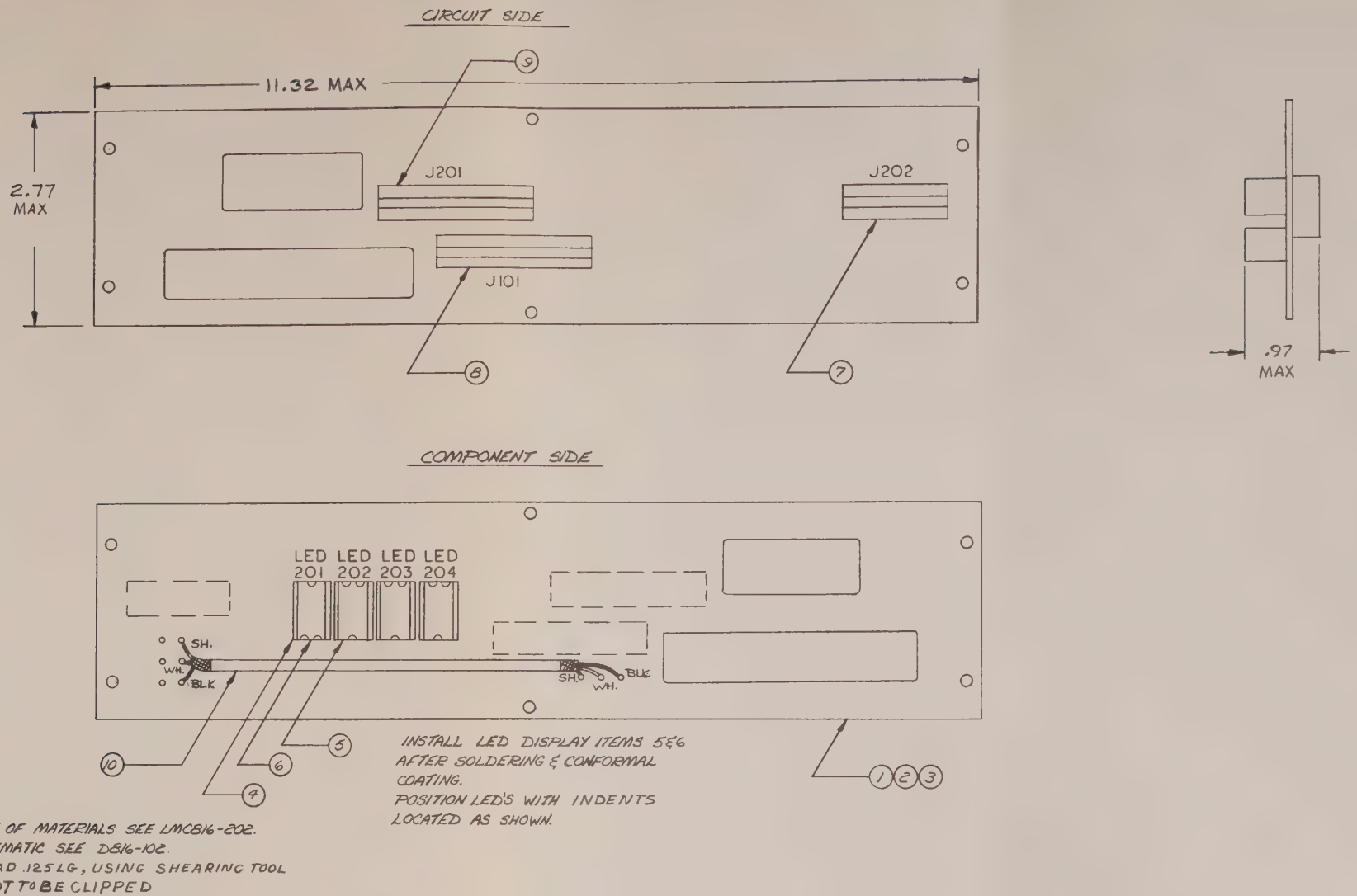


NOTES

1. FOR LIST OF MATERIALS SEE LMD816-201-2
2. FOR SCHEMATIC SEE D816-101
3. AFTER TEST, CONFORMAL COAT ASSEMBLY PER BOWMAR/ALI SPECIFICATION NO. 104
4. MASK (2) 1/4 STRIPS & CONTACT AREA DURING CONFORMAL COATING. MASK ALL TERMINALS ADJUSTMENTS C3, C6, C9, C10, C55 R27, R32, & R78, SWITCH ASS'Y
5. CAUTION: KEEP SWITCH BODY FREE FROM CONTACT WITH OIL, FLUXES, SOLVENTS & EXPOSURE TO TEMPERATURES IN EXCESS OF 550°F

Analog Module Assembly

D816-201-2

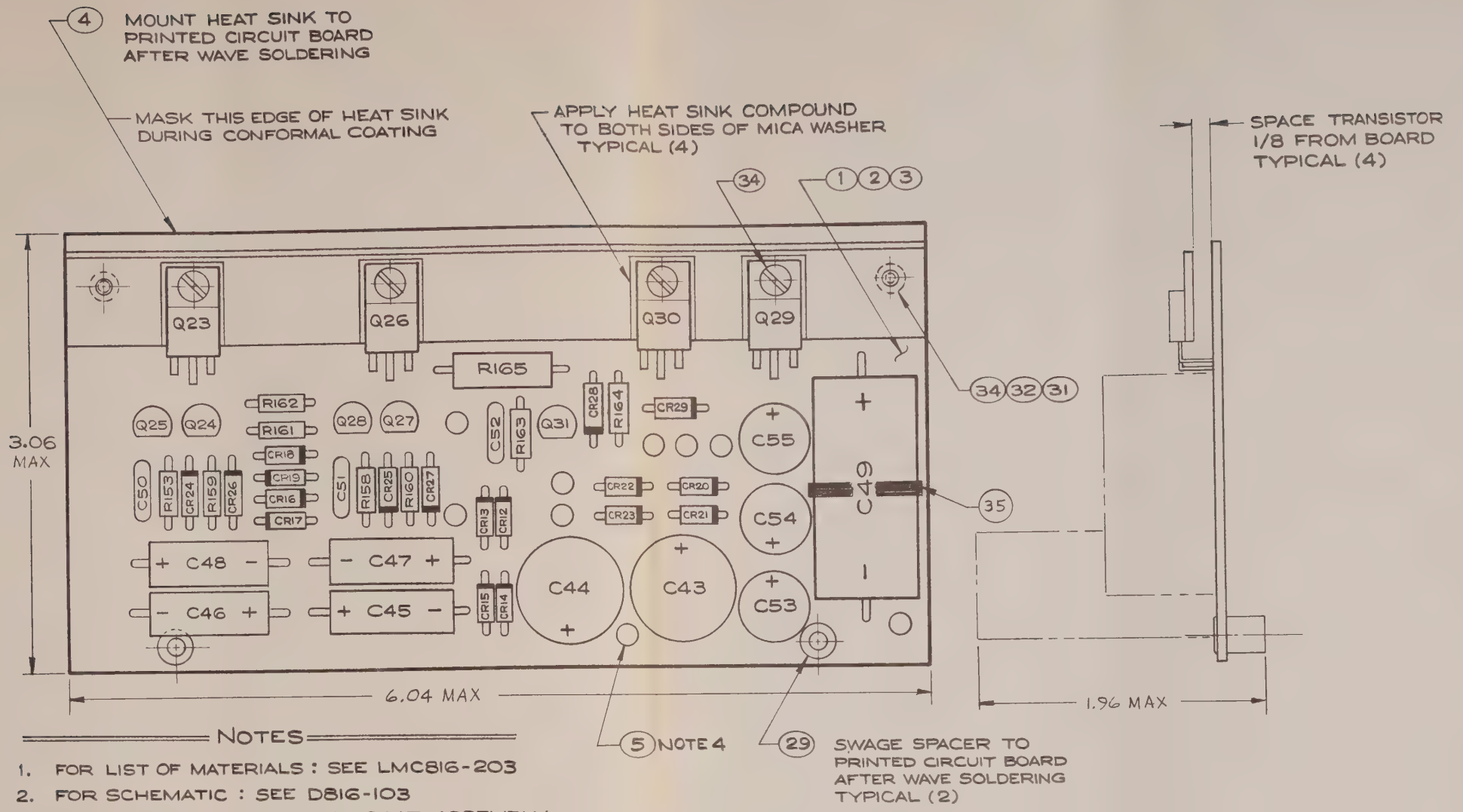


NOTES

1. FOR LIST OF MATERIALS SEE LMC816-202.
2. FOR SCHEMATIC SEE D816-102.
3. CUT LEAD .125 LG, USING SHEARING TOOL ONLY. NOT TO BE CLIPPED

Front Panel Module Assembly

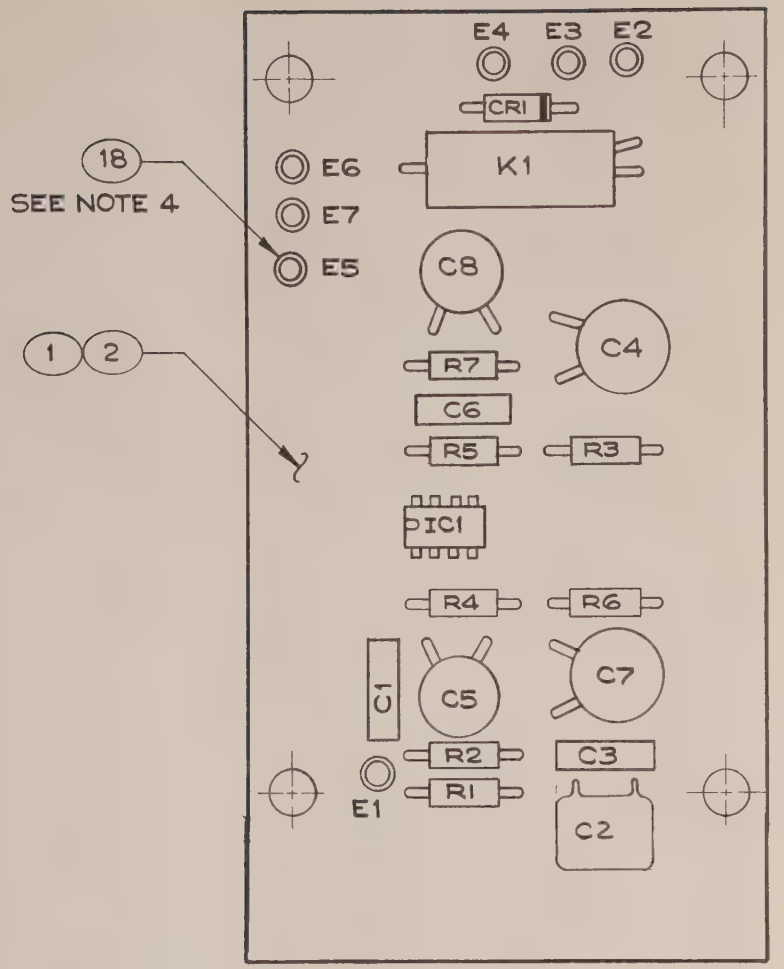
C816-202



NOTES

1. FOR LIST OF MATERIALS : SEE LMC816-203
2. FOR SCHEMATIC : SEE D816-103
3. AFTER TEST, CONFORMAL COAT ASSEMBLY PER BOWMAR/ALI SPEC. Nº. 104
4. MASK TERMINALS, HEAT SINK AS SHOWN & (2) SPACES DURING CONFORMAL COATING.

Power Supply Assembly
C816-203



Notes

1. FOR LIST OF MATERIALS SEE LMC816-205
2. FOR SCHEMATIC DRAWING SEE D816-101
3. AFTER TEST, CONFORMAL COAT ASSEMBLY PER BOWMAR/ALI SPECIFICATION No. 104.
4. BEFORE CONFORMAL COATING MASK E1-E7.

3 KHz Low Pass Filter Assembly

C816-205

CHAPTER 7

PARTS LIST

Items listed herein are electrical and circuit components, grouped under the title of associated modules. With few exceptions, as noted by asterisks, all parts are common to both the 816A-1 and 816A-2 configurations.

Each part is itemized by REF. DES. (Reference Designation), and is described according to title, values, manufacturer, and manufacturer's identification number. Exception to providing manufacturer identification is taken where the part is standardized RETMA. Any manufacturer registered for RETMA parts will be acceptable.

A second list gives manufacturer's names, for convenience of locating specific components or related information.

MEASURING SET ASSEMBLY

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
J1, J2	Binding Post, Red	Grayhill	29-1 (Red)
J3	Binding Post, Black	Grayhill	29-1 (Blk)
J4	Jack	Switchcraft	JJ-022
S5	Switch, Rocker, White Button Bezel P/N7890 Blk	C & K	7201-J50
XF1, XF2	Fuse Holder	Littelfuse	342004
F1, F2	Fuse	Littelfuse	3AG-3/10A
S6	Switch	Switchcraft	46256LFR
TB1	Block, Terminal	Kulka	1696-3/4ST-4
T1	Transformer	Bowmar/ALI	B6098
P2	Receptacle	Switchcraft	AC3G
P203**	Connector, 25 Pin	Cinch-Jones	DB-25P

LOGIC MODULE ASSEMBLY

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
CR1, 2, 3, 4, 5, 8-23, 201-203	Diode		1N914 or 1N4148
CR6, 7	Diode, Zener		1N825
Q1, 2, 3, 5, 6, 14, 16	Transistor PNP		2N3906
Q4, 7, 11, 12, 15, 20	Transistor NPN		2N3904
Q8, 9, 10, 11, 13	Transistor FET		2N5461
IC1	Integrated Circuit UA739C	Fairchild	U6A7739393
IC2, 3, 4, 5	Integrated Circuit 558	Signetics	N5550V
IC6	Integrated Circuit 748	TI	SN72748P
IC7, 8	Integrated Circuit 304	National Semiconductor	LM304

Key: All components are common to the 816A-1 and 816A-2 models except those marked: * for 816A-1 only
** for 816A-2 only

LOGIC MODULE ASSEMBLY (Cont'd)

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
IC201, 202, 206, 214, 239	Integrated Circuit 846	TI	SN15846
IC203, 222	Integrated Circuit 862	TI	SN15862N
IC208	Integrated Circuit 74193	TI	SN74193N
IC209, 215, 235, 236, 237, 238	Integrated Circuit 836	TI	SN15836
IC204, 205, 210	Integrated Circuit 830	TI	SN15830N
IC217	Integrated Circuit	Motorola	MC1812P
		TI	SN7486N
IC218	Integrated Circuit 7483	TI	SN7483N
IC227	Integrated Circuit 8094	TI	SN158094N
IC212, 219, 220, 221	Integrated Circuit 7490	TI	SN7490N
IC211	Integrated Circuit 7400	TI	SN7400N
IC223, 224, 225, 226	Integrated Circuit 7475		SN7475N
IC228, 229, 230	Integrated Circuit 7447		SN7447AN
C9	Capacitor . 1μf, 10%	Mepco/Electra	C280AE/A100K
C1, 5	Capacitor, Electrolytic 50uf, 25V	IEC	PCW50TJ25
C3	Capacitor, . 33μf, 10%	Mepco/Electra	C280AE/A330K
C4, 9, 217	Capacitor, . 001μf, 10%	Mepco/Electra	C280AE/A1K
C6, 8, 12, 14, 15, 18, 21, 22, 24, 26, 27, 28, 29, 30	Capacitor, . 1μf, 20V	Centralab	UK20-104
C23	Capacitor, . 1μf, 5%	S&EI	22UA104J
C7, 11, 205, 204	Capacitor, . 01μf ± 10%	Mepco/Electra	C280AE/A10K
C10	Capacitor, 2pF	CDE	CD6CD020C03

Key: All components are common to the 816A-1 and 816A-2 models except those marked: *for 816A-1 only
**for 816A-2 only

LOGIC MODULE ASSEMBLY (Cont'd)

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
C13	Capacitor, Electrolytic 1.2μf, 25V	Sprague	196D125X9025NA1
C16	Capacitor, Electrolytic 1.5μf, 25V	Sprague	196D155X0025NA1
C17, 202	Capacitor, Electrolytic 1.0μf, 35V	Sprague	196D105X0035NA1
C19, 20	Capacitor, Electrolytic 6.8μf, 40V	Mepco/Electra	ET6P8X040A2
C25	Capacitor, 3pF	CDE	CD6CD030C03
C201, 207	Capacitor, Electrolytic 33μf, 16V	IEC	PCW33T
C206	Capacitor, .047μf, ±10%	Mepco/Electra	C280AE/A47K
C208	Capacitor, DSM 200pF, 500V, 5%		CM04FD201J03
C210, 211	Capacitor, DSM, 100pF, 500V, 5%		CM04FD101J03
C203, 209, 212-216, 218, 219	Capacitor, .1μf, 20V	Centralab	UK20-104
R4, 5, 8, 13, 14, 34, 51, 1	Resistor, 10K, 1%, 1/8W		RN60C1002F
R2, 12	Resistor, 6.8K, 5%, 1/4W		RC07GF682J
R3	Resistor, 5.6K, 5%, 1/4W		RC07GF562J
R6, 7	Resistor, 20K, 1%, 1/8W		RN60C2002F
R9	Resistor, 100K, 1%, 1/8W		RN60C1003F
R10, 16	Resistor, 33Ω, 5%, 1/4W		RC07GF330J
R11, 15, 22, 26, 58, 59, 75, 77, 200	Resistor, 100Ω, 5%, 1/4W		RC07GF101J
R17	Resistor, 24.9K, 1%, 1/8W		RN60C2492F
R18	Resistor, 162K, 1%, 1/8W		RN60C1623F
R19	Resistor, 27.4K, 1%, 1/8W		RN60C2742F
R20	Resistor, 121K, 1%, 1/8W		RN60C1213F
R21	Resistor, 750K, 1%, 1/8W		RN60C7503F

Key: All components are common to the 816A-1 and 816A-2 models except those marked: *for 816A-1 only
**for 816A-2 only

LOGIC MODULE ASSEMBLY (Cont'd)

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
R23, 24	Resistor, 20K, 5%, 1/4W		RC07GF203J
R25	Resistor, 39K, 5%, 1/4W		RC07GF393J
R27, 73, 76, 79	Resistor, 4.7K, 5%, 1/4W		RC07GF472J
R28, 35	Resistor, 1.2K, 5%, 1/4W		RC07GF122J
R29	Resistor, 11.8K, 1%, 1/8W		RN60C1182F
R30, 32	Resistor, 2.21K, 1%, 1/8W		RN60C2211F
R31, 50	Potentiometer 10K	Beckman	62PR10K
R33, 56	Potentiometer 2K	Beckman	62PR2K
R80, 84	Resistor, 220, 5%, 1/4W		RC07GF220J
R81	Resistor, 2.55K, 1%, 1/8W		RN60C2551F
R82	Potentiometer 1K	Beckman	62PR1K
R83, 87	Resistor, 2.43K, 1%, 1/8W		RN60C2431F
R85	Resistor, 6980, 1%, 1/8W		RN60C6980F
R86	Potentiometer 500Ω	Beckman	62PR500
R36, 37, 38, 39, 40, 41, 42, 43, 52, 54, 57, 61, 62, 63, 66, 72	Resistor, 47K, 5%, 1/4W		RC07GF473J
R44, 45, 46, 47, 53	Resistor, 1 Meg, 5%, 1/4W		RC07GF105J
R48	Resistor, 68.1Ω, 1%, 1/8W		RN60C68R1F
R49	Resistor, 1.21K, 1%, 1/8W		RN60C1211F
R55	Resistor, 16.5K, 1%, 1/8W		RN60C1652F
R69, 83, 202, 203, 204, 205, 206, 207, 208, 235, 236	Resistor, 10K, 5%, 1/4W		RC07GF103J
R64, 65, 67, 69, 71, 234, 209	Resistor, 1K, 5%, 1/4W		RC07GF102J
R68, 70	Resistor, 3.9K, 5%, 1/4W		RC07GF392J

Key: All components are common to the 816A-1 and 816A-2 models except those marked: *for 816A-1 only
**for 816A-2 only

LOGIC MODULE ASSEMBLY (Cont'd)

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
R74, 78	Resistor, 2.7K, 5%, 1/4W		RC07GF272J
R201	Resistor, 470Ω, 5%, 1/4W		RC07GF471J
R212-233	Resistor, 180Ω, 5%, 1/4 W		RC07GF181J
R210	Resistor, 82Ω, 5%, 1/4W		RC07GF820J
R211	Resistor, 150Ω, 5%, 1/4W		RC07GF151J
X201	Crystal, 2.0 MHz	International Crystal	B6190
S201	Switch, Pushbutton	Bowmar/ALI	B6060
K6	Relay, Reed	Coto-Coil	U-12-P9
J203**	Connector, 25 Pin	Cinch-Jones	DB-25S

ANALOG MODULE ASSEMBLY

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
C1, 2	Capacitor, Mylar 0.68MFD at 400V	CDE	WMF4P68
C3, 6	Capacitor, Variable 3.8-30.0pF	Johanson	9303
C4, 5	Capacitor, DSM 30pF, 500V, 5%		CM05ED300J03
C7, 8	Capacitor, Polycarbonate .0068MFD, 50V, 2%	S&EI	22UA682G
C9, 10	Capacitor, Variable 1.7-6.0pF	Johanson	9300
C11, 12, 14, 15, 57, 58	Capacitor, .01 MFD	Mepco/Electra	C280AE/A10K
C13, 16	Capacitor, DSM 2pF, 500V, ±1/2pF	CDE	CD10CD020D03
C17, 18, 21, 25, 28, 35, 39, 45, 47, 48, 50, 60	Capacitor, .1MFD, 20V, +80-20%	Centralab	UK20-104

Key: All components are common to the 816A-1 and 816A-2 models except those marked: *for 816A-1 only
**for 816A-2 only

ANALOG MODULE ASSEMBLY (Cont'd)

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
C19, 37, 43, 59	Capacitor, DSM 10pF, 500V ±1/2pF		CM04CD100D03
C22, 29, 32, 40, 51	Capacitor, .33MFD	Mepco/Electra	C280AE/A330K
C23, 24, 30, 31, 33, 34, 41, 42, 52, 53	Capacitor, Electrolytic	IEC	PCW50TJ25
C26, 49, 20	Capacitor, .001MFD	Mepco/Electra	C280AE/A1K
C27	Capacitor, DSM 5pF, 500V, ±1/2pF		CM04CD050D03
C36, 46	Capacitor, .1MFD	Mepco/Electra	C280AE/A100K
C54	Capacitor, DSM, 200pF, 500V, 5%		CM04FD201J03
C55	Capacitor, Variable 2.3-20pF	Johanson	9302
C56	Capacitor, DSM, 47pF, 500V, 5%		CM04ED470J03
CR1, 2, 3, 4, 5, 6, 7, 8, 9	Diode		1N914, IN4148
IC1, 2, 3, 4	Integrated Circuit 739C	Fairchild	U6E7739393
K1, 2	Reed Relay	Coto-Coil	UD-12-P1
K3, 4	Reed Relay	Coto-Coil	U-12-P9
K5	Reed Relay	Coto-Coil	U-12-P1
S1, 2	Pushbutton Switch Ass'y	Bowmar/ALI	B6059
Q1,2,4,5,6,7,8,9,10, 11,12,13,80,82,82	Transistor		2N3904
Q3	Transistor		2N1613
R1	Resistor, 135Ω, 0.1%, 1W		RN75E1350B
R2	Resistor, 600Ω, 0.1%, 1W		RN75E6000B
R3	Resistor, 900Ω, 0.1%, 1W		RN75E9000B
R4, T	Resistor, 178K, 1%, 1/8W		RN60C1783F

Key: All components are common to the 816A-1 and 816A-2 models except those marked: †for 816A-1 only
**for 816A-2 only

ANALOG MODULE.ASSEMBLY (Cont'd)

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
R5, 8	Resistor, 124K, 0.1%, 1/4W		RN65E1243B
R6, 9	Resistor, 887Ω, 0.1%, 1/8W		RN60E8870B
R10, 11	Resistor, 301K, 0.1%, 1/8W		RN60E3013B
R12, 18	Resistor, 39K, 5%, 1/4W		RC07GF393J
R13, 19, 68	Resistor, 33Ω, 5%, 1/4W		RC07GF330J
R14, 17	Resistor, 62K, 5%, 1/4W		RC07GF623J
R15, 16	Resistor, 11.0K, 1%, 1/8W		RN60C1102F
R20, 24	Resistor, 100K, 1%, 1/8W		RN60C1003F
R21, 29, 31, 37, 46, 51, 58, 69	Resistor, 100Ω, 5%, 1/4W		RC07GF101J
R22, 23, 64, 65	Resistor, 10.0K, 1%, 1/8W		RN60C1002F
R25	Resistor, 1.10K, 1%, 1/8W		RN60C1101F
R26, 28	Resistor, 9.09K, 1%, 1/8W		RN60C9091F
R27	Potentiometer 2K	Beckman	62PR2K
R30, 36, 57	Resistor, 150Ω, 5%, 1/4W		RC07GF151J
R33	Resistor, 2.55K, 1%, 1/8W		RN60C2551F
R32	Potentiometer 5K	Beckman	62PR5K
R34	Resistor, 620Ω, 5%, 1/4W		RC07GF621J
R35	Resistor, 300Ω, 5%, 1/4W		RC07GF301J
R38	Resistor, 62Ω, 5%, 1/4W		RC07GF620J
R39	Resistor, 6.10K, 0.1%, 1/8W		RN60E6101B
R40, 44, 49, 61	Resistor, 54.9K, 0.1%, 1/8W		RN60E5492B
R41, 63	Resistor, 2K, 5%, 1/4W		RC07GF202J
R42, 47	Resistor, 5.49K, 0.1%, 1/8W		RN60E5491B
R43, 48	Resistor, 56K, 5%, 1/4W		RC07GF563J
R45, 50	Resistor, 4.7Ω, 5%, 1/4W		RC07GF4R7J
R52	Resistor, 5.46K, 0.1%, 1/8W		RN60E5461B

Key: All components are common to the 816A-1 and 816A-2 models except those marked: *for 816A-1 only
**for 816A-2 only

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
R53	Resistor, 11.5K, 0.1%, 1/8W		RN60E1152B
R54	Resistor, 14.1K, 0.1%, 1/8W		RN60E1412B
R55	Resistor, 560Ω, 5%, 1/4W		RC07GF561J
R56	Resistor, 360Ω, 5%, 1/4W		RC07GF361J
R59	Resistor, 160Ω, 5%, 1/4W		RC07GF161J
R60	Resistor, 25.4K, 0.1%		RN60E2542B
R62, 70	Resistor, 470Ω, 5%, 1/4W		RC07GF471J
R66	Resistor, 2.4K, 5%, 1/4W		RC07GF242J
R67	Resistor, 12K, 5%, 1/4W		RC07GF123J
R71	Resistor, 1K, 5%, 1/2W		RC20GF102J
R72, 73, 74, 75, 76, 100	Resistor, 47K, 5%, 1/4W		RC07GF473J
C17	Capacitor, DSM 470pF, 300V, ±2%	CDE or Equiv.	CD7FA471G03
C78, 84, 88, 93	Capacitor, .01MFD, 20V, +80-20%	Centralab	UK16-103
C78, 82	Capacitor, Polycarbonate .01MFD, 50V, ±2%	S&EI	22UA103G
C86	Capacitor, DSM, 3900pF, 500V, ±5%		SM06FD392J03
C81, 85, 89, 93	Capacitor, .1MFD, 20V, +80-20%	Centralab	UK20-104
C83	Capacitor, Polycarbonate .015MFD, 50V, ±2%	S&EI	22UA153G
C86	Capacitor, Polycarbonate 6800pF 50V, ±2%	S&EI	22UA682G
C87, 90	Capacitor, Polycarbonate 4700pF 50V, ±2%	S&EI	22UA472G
C91	Capacitor, Polycarbonate .056MFD 50V, ±2%	S&EI	22UA563G

Key: All components are common to the 816A-1 and 816A-2 models except those marked: *for 816A-1 only
**for 816A-2 only

ANALOG MODULE ASSEMBLY (Cont'd)

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
IC5, 6	Integrated Circuit	Signetics	N5558V
R77	Resistor, 200Ω, 5%, 1/4W		RC07GF201J
R78	Potentiometer 10K	Beckman	62PR10K
R79	Resistor, 4.99K, 1%, 1/8W		RN60C4991F
R80, 82	Resistor, 17.8K, 1%, 1/8W		RN60C1782F
R81	Resistor, 2K, 5%, 1/4W		RC07GF202J
R83, 89, 94, 99	Resistor, 100Ω. 5%, 1/4W		RC07GF101J
R84	Resistor, 36K, 5%, 1/4W		RC07GF363J
R85	Resistor, 20.5K, 1%, 1/8W		RN60C2052F
R86	Resistor, 7.87K, 1%, 1/8W		RN60C7871F
R87	Resistor, 33K, 5%, 1/4W		RC07GF333J
R88	Resistor, 34.0K, 1%, 1/8W		RN60C3402F
R90	Resistor, 4.75K, 1%, 1/8W		RN60C4751F
R91	Resistor, 9.76K, 1%, 1/8W		RN60C9761F
R92	Resistor, 39K, 5%, 1/4W		RC07GF393J
R93	Resistor, 38.3K, 1%, 1/8W		RN60C3832F
R95	Resistor, 21.5K, 1%, 1/8W		RN60C2152F
R96	Resistor, 31.6K, 1%, 1/8W		RN60C3162F
R97	Resistor, 75K, 5%, 1/4W		RC07GF753J
R98	Resistor, 76.8K, 1%, 1/8W		RN60C7682F

FRONT PANEL MODULE ASSEMBLY

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
LED202, 203, 204	Indicator, Numeric	Monsanto	MAN-10A

Key: All components are common to the 816A-1 and 816A-2 models except those marked: *for 816A-1 only
**for 816A-2 only

FRONT PANEL MODULE ASSEMBLY (Cont'd)

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
LED 201	Indicator, Polarity	Monsanto	MAN-1001A
J101	Connector Printed Ckt 15 Dual Position	AMP	583485-4
J201	Connector Printed Ckt 18 Dual Position	AMP	1-583485-9
J202	Connector Printed Ckt 12 Dual Position	AMP	1-583485-4

POWER SUPPLY ASSEMBLY

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
CR12 thru CR23	Diode		1N4003
CR24, 25, 28	Diode		1N914, IN4148
CR26, 27	Diode, Zener 12V, 5%		1N759A
CR29	Diode, Zener 4.3V, 5%		1N749A
Q23, 30	Transistor NPN	TI	TIP29
Q24, 25, 31	Transistor NPN		2N3904
Q26	Transistor PNP	TI	TIP 30
Q27, 28	Transistor PNP		2N3906
Q29	Transistor NPN	TI	TIP31
C43, 44	Capacitor 1000µf, 35V	IEC	PCW1000PP35
C45, 47	Capacitor 10µf, 75V	IEC	KAW10KE75
C46, 48	Capacitor, 5µf, 75V		KAW5KD75
C49	Capacitor, 2500µf, 15V	Siemens	8212-0-11
C50, 51, 52	Capacitor, 100pF		CM04FD101J03

Key: All components are common to the 816A-1 and 816A-2 models except those marked: *for 816A-1 only
**for 816A-2 only

POWER SUPPLY ASSEMBLY (Cont'd)

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
C53, 54, 55	Capacitor, 100μf, 25V	IEC	PCW100TPH25
R153, 158	Resistor, 27K, 5%, 1/2W		RC02GF273J
R159, 160	Resistor, 47Ω, 5%, 1/2W		RC20GF470J
R161, 162	Resistor, 2.4K, 5%, 1/2W		RC20GF242J
R163	Resistor, 2.7K, 5%, 1/2W		RC20GF272J
R164	Resistor, 10Ω, 5%, 1/2W		RC20GF100J
R165	Resistor, 1.2K, 5%, 1W		RC32GF122J

Key: All components are common to the 816A-1 and 816A-2 models except those marked: *for 816A-1 only
**for 816A-2 only

* 3 kHz LOW PASS FILTER ASSEMBLY

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
C1	Capacitor .015MFD, 50V, ±2% Metallized Polycarbonate	S&EI	22UA153G
C2	Capacitor 2000PF, 500V±2% Silver Mica		CM06FD202J03
C3	Capacitor, 91PF, 500V, ±5% Mica		CM04FD910J03
C4, C7	Capacitor, .1MFD, 20V +80-20%	Centralab	UK20-104
C5, C8	Capacitor, .01MFD, 16V +80-20%	Centralab	UK16-103
C6	Capacitor, .01MFD, 50V, ±2% Metallized Polycarbonate	S&EI	22UA103G
R1, R2	Resistor, 10.2K, 1/8W, ±1%		RN60C1022F
R3, R6	Resistor, 100Ω, 1/4W, ±5%		RC07GF101J
R4	Resistor, 20K, 1/4W, ±5%		RC07GF203J
R5	Resistor, 7.50K, 1/8W, ±1%		RN60C7501F
R7	Resistor, 7.5K, 1/4W, ±5%		RC07GF752J
IC1	Integrated Circuit	TI	N5558V
K1	Reed Relay	Coto-Coil	U-12-P1
CR1	Diode		IN914 or IN4148
E1-E7	Turret Terminal Solder	Cambion	2027-2

Key: All components are common to the 816A-1 and 816A-2 models except those marked: *for 816A-1 only
**for 816A-2 only

LIST OF MANUFACTURERS

Abbreviation	Complete Name and Address
AMP	AMP, Incorporated Eisenhower Boulevard Harrisburg, Pennsylvania 17105 USA
Beckman	Beckman Instruments, Inc. Helipot Division 2500 Harbor Boulevard Fullerton, California 92634 USA
Bowmar/ALI	Bowmar/ALI, Inc. 531 Main Street Acton, Massachusetts 01720 USA
Cambion	Cambridge Thermionic Corporation 445 Concord Avenue Cambridge, Massachusetts 02138 USA
C & K	C & K Components, Inc. 103 Morse Street Watertown, Massachusetts 02172 USA
Centralab	Centralab Electronics Division Globe-Union, Inc. 5757 North Greenbay Avenue Milwaukee, Wisconsin 53209 USA
CDE	Cornell-Dubilier Electronics, Inc. CDE International Marketing 2070 Maple Street DesPlaines, Illinois 60018 USA
Cinch-Jones	Cinch Electronics Division of TRW 1501 Morse Avenue Elk Grove Village, Illinois 60007 USA
Coto-Coil	Coto-Coil Company, Inc. 57 Pavilion Avenue Providence, Rhode Island 02905 USA
Fairchild	Fairchild Semiconductor Components Group 464 Ellis Street Mountain View, California 94040 USA

Grayhill	Grayhill, Inc. 537 Hillgrove Avenue LaGrange, Illinois 60525 USA
International Crystal	International Crystal Manufacturing Company, Inc. 10 North Lee Street Oklahoma City, Oklahoma 73102 USA
IEC	IEC Electronics Corporation 319 East Chestnut Street East Rochester, New York 14445 USA
Johanson	Johanson Manufacturing Corporation Box 329 Boonton, New Jersey 07005 USA
Kulka	Kulka Electric Corporation 520 South Fulton Avenue Mt. Vernon, New York 10551 USA
Littelfuse	Littelfuse, Inc. 800 East Northwest Highway DesPlaines, Illinois 60016 USA
Mepco/Electra	Mepco/Electra, Inc. Columbia Road Morristown, New Jersey 07960 USA
Monsanto	Monsanto - Electronic Special Products 10131 Bubb Road Cupertino, California 95014 USA
Motorola	Motorola Semiconductor Products, Inc. P.O. Box 20912 Phoenix, Arizona 85036 USA
National Semiconductor	National Semiconductor Corporation 2900 Semiconductor Drive Santa Clara, California 95051 USA
S&EI	S&EI Manufacturing 18800 Parthenia Street Northbridge, California 91324 USA
Siemens	Siemens Corporation Components Division 186 Wood Avenue, South Iselin, New Jersey 08830 USA

Signetics	Signetics Corporation 811 East Arques Avenue Sunnyvale, California 94086 USA
Sprague	Sprague Electric Company 481 Marshall Street North Adams, Massachusetts 02147 USA
Switchcraft	Switchcraft, Inc. 5555 North Elston Avenue Chicago, Il'inois 60630 USA
TI	Texas Instruments, Inc. Components Group Box 5012 Dallas, Texas 75222 USA

CHAPTER 8

SUPPLEMENTARY DATA

8.1 Guarantee

Bowmar/ALI, Inc. guarantees to the original purchaser that this instrument is in accordance with applicable specifications. Any deviation from these specifications and any defects in workmanship or materials will be corrected by Bowmar/ALI, Inc., provided the instrument has been properly used under normal operating conditions. This guarantee is effective for one year from date of shipment except for failure of or attributable to tubes, fuses, batteries, or semiconductors after ninety days from date of shipment. Bowmar/ALI, Inc. will be the sole judge of the validity of all claims.

All returns made under this guarantee must be authorized in writing by Bowmar/ALI, Inc. Such authorization will be given only upon receipt of information concerning type, serial number, and the defect claimed. Return shipments must be made prepaid except returns authorized within thirty days from date of shipment, in which case Railway Express Collect will be authorized. All rework done under this guarantee will be reshippe prepaid from our plant.

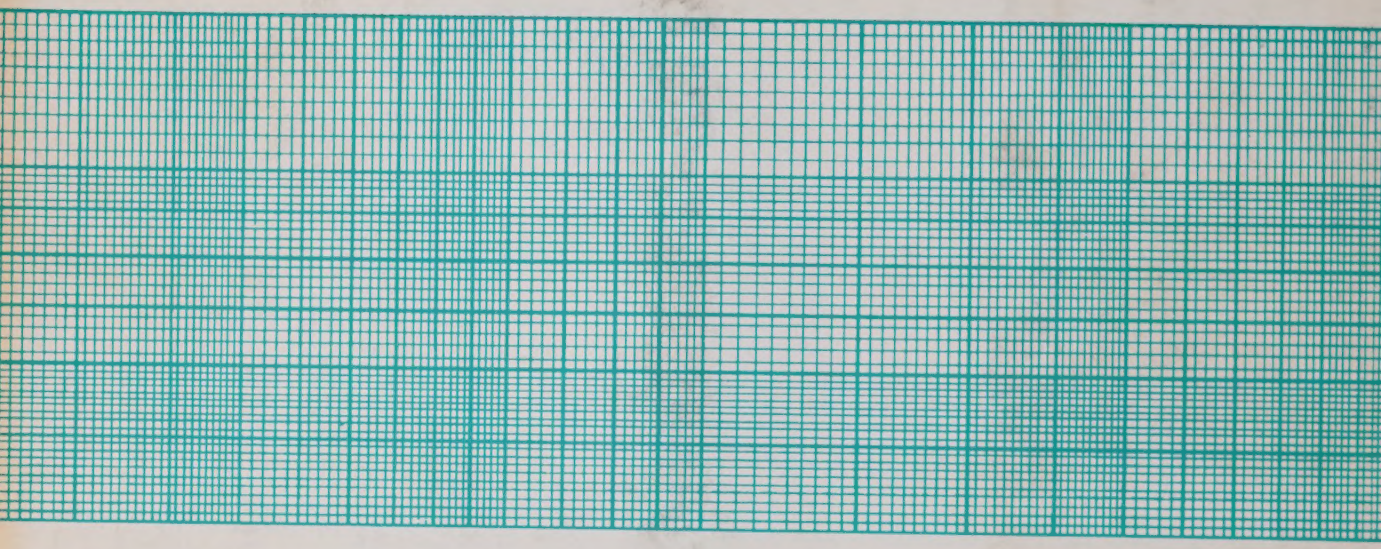
Bowmar/ALI, Inc. will not be responsible for, nor assume any expense or liability for, damage or loss in shipment, loss of profit, or any other damages or claims for which provisions are not specifically made herein.

8.2 Material Damaged in Shipment

Upon receipt of the instrument, do not unpack if the packing case shows evidence of damage; upon unpacking, do not discard any of the packing if damage is found which appears to have been caused by shipment. Immediately notify the local office of the carrier and request that the damage be inspected; also, notify Bowmar/ALI, Inc. of the model number, serial number, carrier's number, date received, and any other pertinent information so that we may contact the local carrier office and facilitate a speedy settlement of any claim.

Address correspondence to:

BOWMAR/ALI, INC.
531 Main Street
Acton, Massachusetts 01720 USA
Telephone: (617) 263-8361



BOWMAR

BOWMAR / ALI, Inc.

A SUBSIDIARY OF BOWMAR INSTRUMENT CORPORATION

531 MAIN STREET, ACTON, MASSACHUSETTS 01720. TELEPHONE (617) 263-8361